spaceflight

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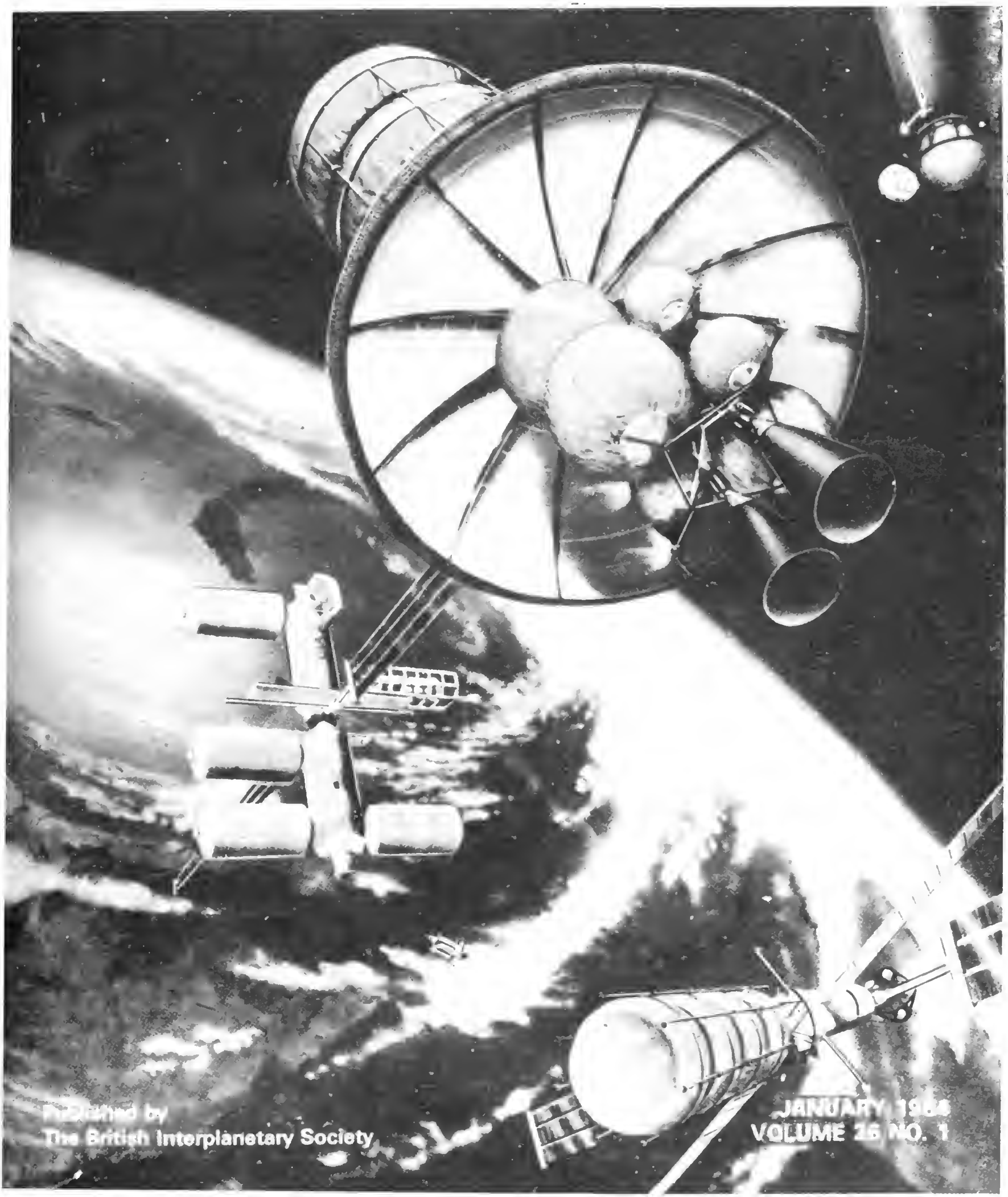
По подписке 1984 г.



spaceflight

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CAN WE COUNT ON YOUR HELP?

Several changes in the appearance, layout and presentation of *Spaceflight* are now taking place, including the use of better-quality paper to enhance the appearance of pictures and more extensive use of colour, created with the aid of professional advisors.

These changes are being introduced to coincide with the introduction of our new word-processors to aid in setting material for publication. The savings made cannot possibly cover the costs of all these improvements, of course, so this provides an added reason why we urgently need to expand our membership base by the introduction of more new members as quickly as possible.

The Council has embarked upon an ambitious course to further the aims, publications and influence of the Society in every possible way. We would like to count on your help with our new membership promotion drive and would ask every member to introduce at least one other person to the Society's work and publications. We have membership application forms and free introductory literature to send to anyone likely to be interested.

Please let us know if you can help.

Members will be interested to know that this issue of "Spaceflight" is the first to be produced using the Society's new word-processor system.

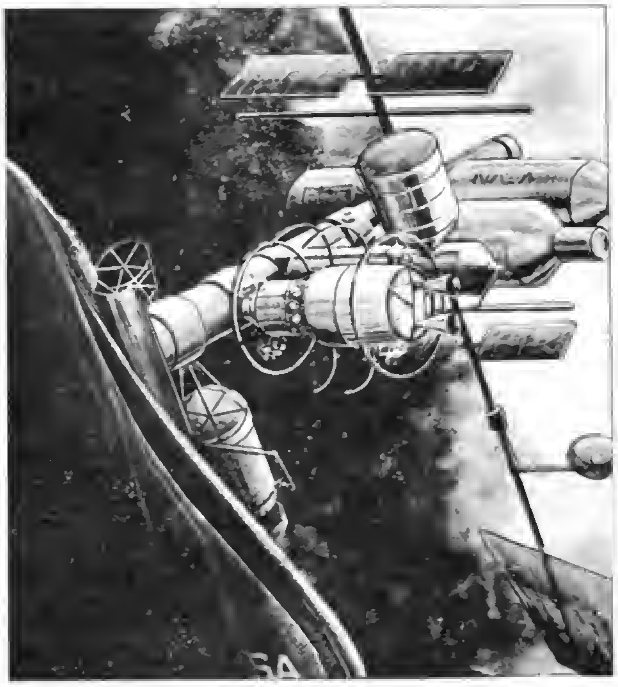
COVER

A vision of the future. A ferry (centre) prepares to leave Earth orbit in the year 2000 carrying liquid hydrogen tank modules at the forward end for delivery to lunar operations. The large circular section is used to brake the ferry back into Earth orbit by aerodynamic drag on return from the Moon. At left is a manned Space Station, bottom right is a store for the liquid hydrogen modules. A modified Shuttle External Tank at top right has carried one of the modules into orbit before transfer to the store. *NASA*

EUROPE AND THE SPACE STATION

By Roy Gibson

The introduction of a permanent US Space Station is the next major step following the development of the Space Shuttle. A "Space Station Symposium" was held in Washington, DC on 18–20 July 1983, organised for NASA by the American Institute of Aeronautics and Astronautics. Roy Gibson, a former Director-General of the European Space Agency, reports on the proceedings for *Spaceflight*.



Introduction

The Symposium was attended by 360 participants, including visitors from the UK, France, Germany, Italy, Canada and Japan. European aerospace industry was fairly well represented, but only Germany and Italy fielded official representatives from Europe. The European Space Agency was present, but not at a level commensurate with the four and five star NASA representations.

Unlike many such events, the participants were obviously there to participate; all the sessions were extremely well attended.

In his opening address, Jim Beggs, NASA Administrator, emphasised that US supremacy in space was being challenged by an increasing number of nations and that the US could not hope to maintain its present position simply by improving the capacity of the Shuttle. He indicated reasonable assurance that an early start would be made on a Space Station programme, and that it was unlikely to be the subject of political party wrangles. NASA, Beggs said, hopes "to attract the international community into this endeavour – this is an essential part of the programme." For me, however, the declaration lost some of its charm by the frank addition of the comment that international spending in this way would avoid duplication and competition with the US.

Several contributions combined to give a clear idea where NASA presently stands in relation to the Space Station. First came a resumé of the eight study contracts which NASA has placed with US industry, and the subsequent two weeks of discussion in May with industrial project teams, NASA centres and potential international participants. The object was to develop a draft of the requirements model for the period 1991 to 2000, which will be continuously re-cycled. Table 1 summarises the US anticipated domestic requirements for a Space Station at 28.5 degrees. It is necessary to bear in mind that this represents only the second iteration in a process that will continue until specifications are frozen – and beyond, if other programmes can be taken as precedents.

Assessing the Station

It is not easy to understand the maze of committees and groups involved in assessing Space Station in the US. The focus within NASA is the Space Station Task Force (whose Director is John Hodge) reporting in the first instance to the Associate Deputy Administrator (Phil Culbertson), but with members from most, if not all, NASA centres and from the other functional directorates in NASA headquarters. (Incidentally, NASA seems to be more united than a decade ago, and although there is still a good deal of private enterprise in the centres, one has the feeling that the various efforts are all more or less in the same direction. NASA admits to 250 staff working full-time on Space Station, but unofficially no-one disputes that the real figure is much nearer to 1,000. Estimates of industrial manpower engaged in Space Station related work are harder to come by, but clearly the total industrial effort must be superior to that of NASA. On past performance, much of the industrial work is paid for by company funds.)

Co-ordinated by the Task Force, there are groups translating user needs into hardware requirements and concept development. Representatives from the aerospace industry appear to have regular access to these groups.

In parallel to Hodge's Task Force, there is a commercialisation task force (under Bud Evans) which was due by the end of 1983 to report on the measures needed to help companies get into the space business.

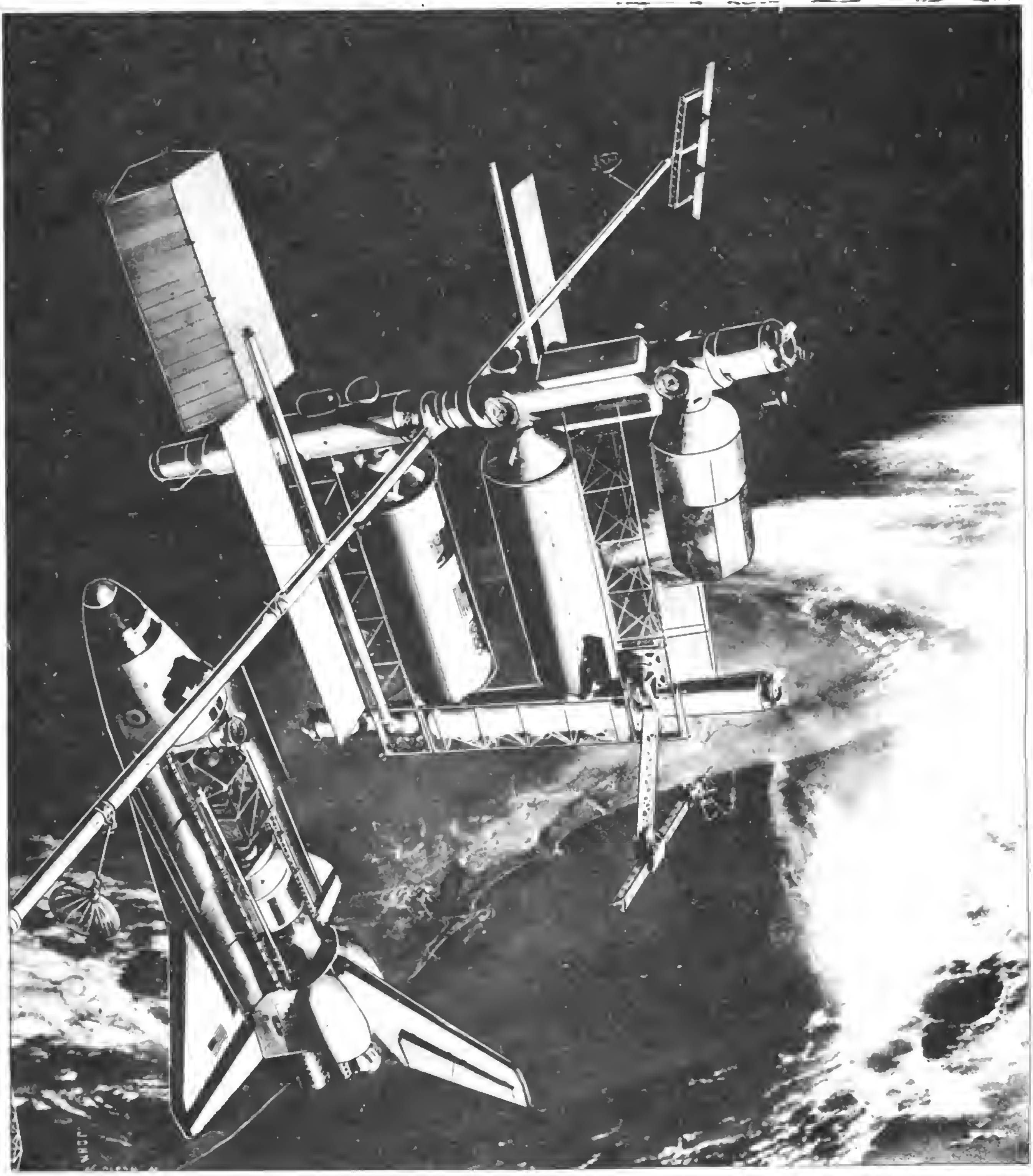
The main policy-formulating body is the Senior Interagency Group (SIG) which consists of senior officials from NASA, DOD, the State Department and all the other departments and agencies which might be involved in some aspect of a Space Station decision. It is this body which, among other things, will recommend to the White House the extent to which international participation in the programme is desirable and feasible.

One must not, of course, neglect the Congress apparatus now being established in preparation for the expected NASA budgetary submission. Apart from the staff members of the House Committees who are presently active in assembling information for their masters, the Congressional Office of Technology Assessment has created its own Space Station Panel with a dazzling array of names, including Van Allen, Sagan and Moya Lear.

Industry, too, is organising its lobbying, as witness the formation of a space commercialisation task force by the National Chamber Foundation, an affiliate of the US Chamber of Commerce. (This group gained its first success in August when it gave an extensive briefing to President Reagan.)

TABLE 1. A summary of US requirements for a 28.5 degree inclination Space Station. (The numbers in parentheses under the "Pressurised Modules" heading indicate the number of commercial production units provided by industry.)

Year	Mass Kg	Pressurized Volume m^3	Power kW	IVA hrs	EVA hrs	# Pressurized Modules	# Attached Payloads # Ports	# FF Servicing	# Transportation Events
1991	35900	195	55	12300	830	4(2)	6/2	3	-----
1992	49900	195	60	12900	1450	4(2)	13/3	3	-----
1993	55000	215	63	16600	1520	5(3)	12/4	3	-----
1994	61000	275	88	24800	1330	8(5)	11/4	2	4
1995	101000	275	101	25200	230	11(8)	7/4	2	6
1996	107000	310	106	29500	160	14(10)	10/4	2	12
1997	101000	305	121	30200	150	14(10)	8/4	1	10
1998	99000	305	112	27400	140	14(10)	5/4	2	13
1999	96000	370	130	27500	110	15(10)	2/2	2	14
2000	94000	365	129	26900	70	15(10)	2/2	2	14



To all of these must be added the more conservative groups fielded by the National Academy of Sciences, whose Space Science and Space Applications Board are both heavily involved (at NASA's behest) in examining the utility of a Space Station.

Even if the inventory is not complete, it ought to be sufficient to show that the current examination of Space Station is very widely based and, as the NASA symposium in particular indicated, has already built up a considerable head of steam.

Perhaps realising that the participants would become prematurely inebriated by any more up-beat presentations, representatives of the National Academy of Sciences were then invited to recount the reactions of their distinguished peers. The Chairman of the Space Science Board bluntly said that space science cannot be regarded as a major justification for a Space Station. A manned Space Station in low Earth orbit (LEO) could be useful for recuperating, servicing or repairing scientific satellites, but US scientists are fearful that the high cost of Space Station would mean a reduction in the space science funding, without any corresponding advantages. They moreover fear a further move in the direction of standardisation of scientific experiments to make them compatible with the system (an earlier criticism of Shuttle/Spacelab). In spite of this negative attitude, however, the scientists had proceeded to identify the characteristics a Space Station would need to have in order to benefit space science. (I hope it is not unfair to characterise their attitude as "Well, since you have decided to build the thing anyway, at least make sure that it has this and this, otherwise it will be absolutely no use at all for space science".) In general, as might be expected, they favour high inclination and long duration, and place great emphasis on purity and stability, plus the ability to handle extremely high data rates.

The Chairman of the Space Applications Board explained that, instead of looking for justifications for a Space Station, his Board had consulted 30 representatives of user groups and had tried to analyse and categorise their reactions. Except in materials sciences and engineering, there was no enthusiasm for a permanent manned presence. Such support as there was for a Space Station came in connection with the capacity to repair and service satellites, plus an interest in the ability to erect large structures in space. For materials science and engineering, however, there was solid support for a permanent manned laboratory with large electric power and cooling facilities, and the possibility of having on board both professionally qualified staff and technicians.

As a supplement to his faithful report of the Board's interim recommendations, the Chairman added some interesting personal impressions:

1. Most remote sensing needs a high inclination orbit, and a propulsion capacity to cater for special orbit requirements is essential;
2. Space station funding must provide resources also for experimentation and not simply for the system itself;
3. Space servicing is an area which should be explored further;
4. There would be an interest in developing the concept of "telepresence", i.e. the use of advanced remote control techniques to allow scientists themselves to conduct complicated experiments without the constant need for man in space.

The much-awaited attitude of the DOD towards the Space Station was presented in almost slap-stick fashion by two senior representatives. Shorn of its flippancy, the DOD stand was clear: DOD conducts its own analysis of its total needs and these do not at present include the Space Station. Space Command, along with all the other commands, has made its bid for funding and, although a good slice of the $2,100 million in the 1985 Defence Budget has been earmarked for "space activities", nothing has been included specifically for the Station.

This said, the speakers stressed the importance of waiting for the recommendations of the President's panel on new defensive technologies (of which Jim Fletcher, a former NASA Administrator, is Chairman) which was appointed after President Reagan's so-called "Star Wars" declaration. Recommendations were expected to be presented to the White House in October.

The DOD is also obviously suffering from the same contagious disease as many space users on both sides of the Atlantic. It takes the form of repeated negative utterances and attacks are provoked by a chronic fear of having to use their own budget for "space". A miracle cure is generally forthcoming either in the guise of an additional allocation of funds from on-high or, in more stubborn cases, when the inevitability of the space system becomes inescapable.

Philosophical generalising aside, there is no doubt that NASA cannot at present cite DOD support in any submission to the White House. The most optimistic public statement was DOD's willingness to hold NASA's coat.

At this point in the symposium, spirits were rather low, but the NASA Task Force Director found it possible to be publicly buoyant on the basis that the attitude of these same speakers had been infinitely more negative a year ago.

The Justification

There followed a series of more optimistic (if less authoritative) presentations describing potential utilisations of a manned space station in various fields: life sciences, Earth sciences, telecommunications, pharmaceutical manufacturing, materials processing, construction assembly base and maintenance and repair. Most of the material will already be familiar to readers, but I should like to high-light two areas: pharmaceutical manufacturing and maintenance repair.

McDonnell Douglas (James T. Rose) gave an interesting description of their electrophoresis continuous flow work started in 1977, which is now covered by a Joint Endeavor Agreement whereby NASA provides free Shuttle flights for the experiments. Ortho Pharmaceutical is the McDonnell Douglas partner and, according to Rose, at least one new product, with worldwide market potential, has already been identified and others are in the pipeline. A manned Space Station, they estimate, would cut production costs to one third of Shuttle and would permit five times as many new products to be developed. They nevertheless have a back-up plan to go into pilot production using only the existing Shuttle facilities. In any event, they expect the first product to be produced in quantities sufficient for clinical trials by 1985, and plan to have Food and Drug Administration certification in 1986. These few lines do scant justice to what is patently an extremely carefully planned business operation which has survived the searchlights of a double corporate examination. As a total justification for the manned space station, it is, of course, insufficient, but it provides a case study worthy of more detailed study by other

candidate commercial users.

Maintenance and repair was virtually the only Space Station capability which drew universal support. Details were given of one interesting example: the repair of the Solar Maximum Mission spacecraft scheduled for the Shuttle flight in April 1984, and more generally NASA gave a thoughtful account of what servicing and repair functions could be envisaged. From this emerged the advantage of making an early start in developing and standardising service equipment which could be reflected in future spacecraft design.

The international aspects of the programme were aired during a panel in which representatives of ESA, Germany, Italy, Canada and Japan participated with NASA. Each explained the status of Space Station planning and the degree of interest so far manifested. So far as Japan and Canada are concerned, they seem to be methodically examining the possibility of participating in the programme and expect to be able to match NASA's decision timetable (decision in principle by the end of 1983 and details negotiated by the end of 1984). Neither appears to have found any convincing *a priori* commercial or other justification for a manned Space Station at this time, but both appear to be continuously favourable to participating.

The West German representative gave a well-constructed list of conditions under which Germany would be prepared to participate (need for an umbrella intergovernmental agreement giving fair balance of advantages and responsibilities to both partners; full use of existing hardware; ability of German industry to compete for work; possibility of independent use of the system), and said that Germany could be ready for a decision in the autumn. One sentiment expressed merits particular attention: Germany places emphasis on retaining its lead in this area and wants to become an attractive partner to the US in both the development and operational phases of the programme.

The Italian presentation was oriented more to an airing of Italy's national space programme, with emphasis on Italy's interest in tethered satellites, but was intended to indicate a general willingness to cooperate with the US in the programme. (Mention was made of the embryonic Italo-German cooperation programme "Columbus", a free-flying manned platform, but very little concrete information was available.)

ESA's contribution was a description of the work so far undertaken in the Agency's Long-term Preparatory Programme (LTPP). Interest registered in Europe in the various fields mirrors that in the US (though, of course, military use has not been examined by ESA), with the strongest support in microgravity research. It was hard to escape the impression that the work the Agency has so far funded in industry (there is practically no in-house effort) is insufficient to allow a considered decision to be taken in the timescale advertised by NASA. For a UK national it was particularly disappointing to note that the British contribution to ESA's LTPP is 4 per cent, one per cent less than that of Spain. Whatever the justification of this figure may be, and I realise that it was not arrived at without due reflection, it is sufficient to provide UK industry with about one full-time engineer on the programme. Even if the NASA timetable proves to be optimistic, there will be decisions to be taken in 1984 which require considerably more background analysis than is presently available.

Although they made no presentation at the NASA symposium, France's space policy was mentioned several times, and it will obviously be one of the crucial factors in determining a European attitude. It was remarked that the presentation in July of the new CNES Medium-Term Plan (to cover 1985–1990) showed a new and strong interest in manned space flight. Moderating the earlier advocacy for automatic spacecraft, the Plan clearly recommends that France develop, or participate substantially in the European development of, a manned space capability based, of course, on Ariane. Collaboration with a US Space Station programme is by no means excluded by the Plan, but there must be convincing evidence that the US system would be open to European access, otherwise a "go-it alone" approach is recommended.

The symposium was brought to a close with a loose promise to repeat the meeting in a year's time, and a summary which reiterated NASA's plan to press for at least a limited start on the programme before the end of 1983. It brought out the strength of the school which holds that, by its nature, the most important justifications for the Space Station cannot be identified before it is available. Whilst one has sympathy with the underlying wisdom, such home-spun philosophies are not normally attractive to the Treasury.

European participants were left with the problem of deciding what action needs now to be taken nationally and regionally. This, in turn, to a certain extent, depends on one's assessment of what is going to happen in the US. Having heard the symposium participants (on and off stage) and having had the benefit of wider discussions in the US, I am convinced that some sort of start will be authorised within the next 6–12 months. Or, more precisely, financial approval will be given to legitimise what is already taking place and formally to recognise that a start is being made in the Manned Space Station programme. The programme will need to opt for a distributed architecture composed of manned modules, attached unmanned platforms, free flyers and tethered spacecraft, all tailored to use the existing Shuttle, whilst developing an orbital transfer vehicle (to get payloads into geostationary orbit) and a teleoperator manoeuvring system. Only in this way can NASA assimilate those who prefer an evolutionary approach from existing hardware, rather than a quantum jump.

How are we to react in Europe? It is already revealing that one has to speak of reacting, i.e. taking action in the light of actions already taken by another, but such is the situation. Many see a parallel with the early 1970's, when Europe's efforts to agree a concerted line of action took so long that the choice options became progressively limited. For me the situation is different: the technologies to be associated with the Space Station cover a wider spectrum than a decade ago, and they are more clearly exploitable in non-space areas. The system itself will be more complicated and hence it will be harder to define the conditions under which international participation (which is different from utilisation) would be acceptable both for the US and for Europe. From this it follows that those responsible for making the decisions need even more information than the last time around – and in a form where prejudices are either eliminated or at least frankly identified.

With the arrogance characteristic of an outsider shorn of power and responsibility, I really do not consider that the necessary measures have been taken to ensure a balanced evaluation at a European level. The disproportionately high effort in Germany and France (I cannot properly judge the current Italian effort) is likely, in my view, to lead either to a greatly reduced role for ESA or an ESA programme based on a prior Franco-German carve-up. As a European, and even as an expatriate Briton, I view neither possibility with enthusiasm.

MILESTONES

September 1983

26 The failure of the Inertial Upper Stage on STS-6 was caused by heat from the second stage nozzle rupturing the 'cushion' used in steering the nozzle, it is revealed. Test firings of modified thermal protection could delay the next IUS flight until summer 1984; Shuttle mission 12 might be cancelled.

28 It is announced that IRAS (Infrared Astronomical Satellite) has discovered its fifth comet, designated Comet IRAS 1983O. It was first detected on 28 July but poor viewing conditions meant that Earth-based telescopes could not view it; a second IRAS detection came on 2 September. The motion indicated a comet and on the 11th observers in New Zealand picked it up. This is the first time that a comet has been discovered and its orbit calculated from observations by a satellite.

28 The intended Soyuz T-10 spacecraft is pulled away from its launcher by escape rockets seconds before the booster explodes. The mission from Tyuratam was to take cosmonauts Titov and Strekalov to visit the Salyut 7 space station. The mission was either to replace Lyakhov and Alexandrov aboard the station or swap the new Soyuz T-10 with the ageing Soyuz T-9 craft. On 9 September a leak aboard Salyut 7 left the station with 50 per cent less control thrusters.

October 1983

1 The 25th anniversary of the official creation of NASA.

4 The 26th anniversary of the first artificial satellite, Sputnik 1.

10 It is reported that the flight of an Indian cosmonaut to the Salyut space station is planned for next April. Ravish Malhorta and Rakesh Sharma are in training for the mission.

10 Film from the STS-8 mission in August shows that the Indian Insat 1B was struck by an unidentified object, it is reported. A solar array later had deployment problems.

10 The Soviet Venera 15 probe, launched on 2 June, enters orbit around Venus. It is joined by Venera 16 on 14 October. It is believed a radar mapping of the surface will be carried out.

14 NASA announces that the STS-9/Shuttle mission might be postponed from its launch date of 28 October because potentially serious problems were discovered with the STS-8 boosters following post-flight analysis.

17 NASA's TDRS 1 communications satellite, launched by STS-6 in April, reaches its final orbital position over the Atlantic. It will be used to link the Spacelab 1 mission with ground control.

18 The Ariane L7 rocket launches the Intelsat V-F7 communications satellite into orbit. The Ariane L8 launch is set for mid-December. The first Ariane 3 version is scheduled for L10 next March, carrying the ECS-2 and Westar 6 communications satellites.

DO YOU KNOW?

This circular body with protruding arms is not seen too clearly in this TV picture. Can you identify what it is?

Novosti

Answer: It shows the Salyut 7 space station as Soyuz T-9, crewed by cosmonauts Vladimir Lyakhov and Alexander Alexandrov, moves into dock on 28 June 1983.

DO YOU REMEMBER?

25 Years Ago...
18 December 1958. Project Score satellite is put into orbit and relays a taped Christmas message from US President Eisenhower. This is the first human voice to be transmitted from space.

20 Years Ago...
21 December 1963. Tiros 8 is launched from Cape Canaveral by Delta rocket. The satellite operated until July 1967 and returned over 100,000 meteorological photos.

15 Years Ago...
9 January 1969. NASA formally announces the crew of Apollo 11, the first manned lunar landing attempt. Astronauts Armstrong, Aldrin and Collins were launched to the Moon 16 July 1969.

10 Years Ago...
25 December 1973. Skylab 4 astronauts Carr and Pogue perform a 7 hour EVA during which Comet Kohoutek is photographed.

5 Years Ago...
4 January 1979. Voyager 1 begins a three months of observation of the planet Jupiter and its moons. Closest approach to Jupiter comes on 5 March 1979.

K.T. WILSON

FROM THE SECRETARY'S DESK

Publicity

References to Society publicity in *Spaceflight* remind me that this subject is not always sweetness and light. An example from many years ago which sticks in my memory concerned permission given by the Society to reproduce a very interesting far-sighted paper by Les Shepherd on "Interstellar Travel" in the pages of an American pulp magazine. The only proviso was that acknowledgement was to be made to the Society.

The copy of the magazine arrived, reprinting our paper but without acknowledgement to the Society, though the editor assured us that one was there. After searching through the magazine four times it was discovered, microscopic in size, almost a smudge, and totally illegible.

Halley's Comet

The quote of the littly ditty by Dr. Hughes in his article on Halley's Comet to be published in *JBIS* reminds me that the second part is, probably, the more important, because it sets out exactly how Halley's name ought to be pronounced.

The ditty runs:

Of all the comets in the sky,
there's none like Comet Halley,
We see it with the naked eye,
periodically,
The first to see it was not he,
but still we call it Halley,
For the notion that it would return was his,
originally.

Coming Your Way

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The Council has set an ambitious course to promote the aims, publications and influence of the Society in every possible way. But we do need your help.

Library Collection

Collecting material for our Library goes on, quite unheralded, day by day, with odd pieces being found and inserted rather in the manner of assembling a giant jigsaw. We spend a lot of time trying to identify books we want, and even more in trying to find copies afterwards.

We seem to keep abreast of current material fairly well but for much of the time, we have to contemplate gaps in our collection. At the moment it is in comets, meteors and minor planets, sc if any member can help us to get books in these areas, either in English or foreign languages, we would be interested to know about it.

We often wonder, too, if any of our readers have come across coins, medallions and medals to do with comets? Plenty of these have been issued in the past, but where are they all now? Some time ago we saw displayed a comet wine bottle. It looked fascinating. If any member finds something similar, please snap it up for us. This is just the thing we would like to have for putting in a future display.

Chesley Bonestell Paintings

Many members will be pleased to see that the Society now sells a slide set, with cassette, containing no less than 40 of the wonderful paintings by Chesley Bonestell. Cheley's paintings appeared in a whole series of books beginning with *The Conquest of Space*. These aroused such public interest and enthusiasm that they must have accounted for much of the public support which helped America in its initial space programme. Chesley received the Society's Bronze Medal for his labours.

These slides will help members to recall those exciting days with pictures both interesting on their own account and beautiful as works of art.

Sad to say, members were deprived of an opportunity of seeing the originals many years ago. The Society had approached the Director of the Tate Gallery to discuss mounting an exhibition of Chesley's works. It was declined on the grounds that the paintings "while of interest in relation to their theme, do not seem to have great quality of works of art, which is our concern!"

UK members may recall that the Tate Gallery later put on display piles of loose bricks. These, apparently, met their stringent requirements.

Vauxhall Space Centre

I discovered the other day that our headquarters is often referred to by the locals as "The Space Centre." We have never thought of it in this way, ourselves, but it sounds *very* flattering.

High Flyer

Problems of rocket take-off failed to appear in *Heliondе: Adventures in the Sun* by S. Whiting, published in 1866, which I perused recently as part of my attempt to update my reading. This particular hero didn't soar into the air like Lucien, nor ascend in a basket swung from the heavens as recorded in the Persian Tales. Nor even did he fly from Crete and perish in the sea like the son of Daedalus.

He started by being ill and, seeking the hand of a bride-to-be, had to face (as we all do) the requirement of making a fortune to keep her in the manner accustomed. "Go into the world and endeavour to obtain some fixed and permanent employment" was the advice given. Our hero had other ideas. He went to the sanitorium instead. There, the Sun's piercing rays "permeated my entire system, dissipated into vapour what little remained of the body corporate and literally dragged me up."

Thus, the upward and onward movement was generated-with arrival in due course at Heliopolis (on the Sun) to discover its flora, fauna and God-like beings.

Goddard's Launch Site

Sir, I recently returned from Roswell in New Mexico in preparation for my next Smithsonian publication, on Robert Goddard, the US rocket Pioneer. I got out to the original launch site, but with great difficulty. It is not exactly a tourist area. In fact, it really is in the middle of nowhere and can be found only with a guide. I had two of them and one lost his way! You have to go over miles and miles of this desert ranch and that. In our first attempt to find it, we spotted a buzzard eating the remains of some poor hapless animal. That will give you some idea of the terrain.

The launch spot itself has a beauty all its own, nonetheless. Although called Eden Valley, the land is endlessly flat. It is hardly a garden of Eden! But it is absolutely peaceful, save for the occasional buzzing of a desert insect. The quietness of the place certainly adds to its aura. My guide on that occasion, a local rancher with a deep interest in history, called it "hallowed ground."

Naturally I took pictures. While doing this, my guide started collecting some scraps of metal and wire scattered about the site — obviously crashed rocket parts. Together, we also found broken milk bottles, a sardine can, and what appeared to be the corner of Goddard's old corrugated iron-covered shelter. This corrugated piece had bullet holes through it and had evidently been used for target practice (whether by Goddard himelf or his handymen I do not know at this point). We also found the spent shells! I guess they had to do something in between rocket launches!

Believe me, these "artefacts" could not have been left by tourists. As I've said, the place is quite remote and hardly the place for anybody, not even a rancher, to come out and consume sardines and drink milk.

FRANK H. WINTER
National Air & Space Museum
Washington, D.C., USA

Why No Spacesuits

Sir, When we see pictures of Shuttle astronauts travelling out to the launch pad for a mission no-one seems to wear a spacesuit. Yet all through the Mercury, Gemini and Apollo programmes they did. Why the change?

SUE MANDRY
London

The quick answer is that they don't need to any more since the Shuttle is designed to fly with "shirtsleeve" astronauts. Only if there is a job to do outside the Shuttle will a Mission Specialist astronaut don a suit kept in the airlock at the rear of the crew cabin — a feature earlier, smaller, spacecraft did not have.

We used to see the earlier astronauts wearing spacesuits with their visors clamped down before flights because US spacecraft used oxygen atmospheres. Look at pre-flight pictures of Soviet cosmonauts, who piloted craft with oxygen/nitrogen atmospheres, and their faceplates are usually open. The US approach — while much simpler to design because only one gas was involved — raised the old divers' problem of 'bends' as the cabin pressure reduced following launch. The solution was to wear the suits for several hours before launch, breathing pure oxygen to flush the nitrogen out of the bloodstream.

The Shuttle now uses oxygen/nitrogen so no 'pre-breathing' exercises are needed. But, if an astronaut does have to wear one of the Shuttle suits for a spacewalk, he/she has to stay in the airlock for several hours because the suits still use only oxygen. Adding nitrogen would make the design too complex but NASA are working on a suit that can operate with higher pressures inside, cutting down the time needed to rid the bloodstream of its nitrogen.

At launch, all the Shuttle astronauts wear helmets which would provide a supply of oxygen over their faces if the cabin began to depressurise.

An Extra Mercury?

Sir, I recently read that NASA considered flying an extra manned mission in the Mercury programme during the early 1960's. Can you throw any light on this?

R. SWEETMAN
London

There certainly was a possibility of flying a Mercury MA-10 mission after Gordon Cooper's 22 orbit flight in May 1963. Alan Shepard would have got the mission and the name "Freedom 7II" was painted on Mercury capsule 15 in preparation. However, NASA saw little point in another extended mission (possibly of three days) and it was officially announced on 12 June 1963 that there would be no MA-10. It is believed that Shepard was given command of the first manned Gemini flight (possibly flying with Tom Stafford), but an inner ear condition took him off the active astronaut list. He had to wait until Apollo 14 in 1971 to get into orbit.

The Geosynchronous Orbit

Sir, Being, as you know, a history of astronautics buff, I have always wondered who can claim to the title of the geosynchronous orbit for satellites.

F.A. Tsander, 1-5 October 1924, in a series of lectures in "the Physics Institute of the First Moscow University," states, with reference to such satellites, "Their distance ... at 42,000 km altitude = $6\frac{2}{3}$ r_e — 24 hr around the Earth." This statement I find in *From a Scientific Heritage*, F.A. Tsander. NASA TT F-541, Washington DC: National Aeronautics and Space Adminitration, 1969, p. 36.

M.R. SHARPE
Alabama, USA

"Where are They?"

Sir, The recent "Horizon" programme on BBC Television and in particular the discussion on "Remote Viewing"* makes it interesting to speculate as to whether this might perhaps provide an answer to the apparent lack of evidence of extraterrestrial intelligence in the Galaxy. If the phenomenon of Remote Viewing in fact constitutes an area of Physics of which we have virtually no knowledge (and I am quite prepared to believe that this is not only possible but likely) then it is not too great a problem to accept that extraterrestrial beings could well have

developed this ability to a high degree. If this were so then Planet Earth may well have been "visited" in the past, or such "visits" may now be taking place or they may occur in the future. Until we ourselves fully develop this ability (if, in fact, it exists) we are unlikely to know.

While appreciating the forceful arguments of Martin and Bond ("Is Mankind Unique?", *Spaceflight*, June 1983), I have to admit to a very strong feeling that it is inlikely that we are the only form of intelligent life in the Galaxy, though I am bound to say that the idea of a Universe teeming with extraterrestrial intelligence is not too convincing. If the latter were the case then it would seem reasonable to suppose that contact of some form or other would have been made along more orthodox lines than those I am suggesting.

A.P. BLACK
Bucks

* The apparent ability of certain people to describe, under laboratory conditions, places and events miles away.

Astronaut Selection

Sir, I read in the January 1983 issue (p. 23) that US astronaut William Fisher, who was selected in 1980, was not called for an interview when he applied in 1978. No so: Fisher visited the Johnson Space Center 7–11 November 1977 "for a week of physical examinations and individual interviews," according to a NASA news release of 1977. A number of other astronauts of the 1980 selection were also interviewed for the 1978 selection. They are: Bagian, Blaha, Bridges, Dunbar, (Guy) Gardner, Grave, Lounge, O'Connor, Richards, Ross and Springer. Furthermore, both Byron Lichtenberg (Spacelab 1 payload specialist) and Mary Helen Johnson (Spacelab 3 payload specialist candidate) were interviewed in 1977.

BERT VIS
Netherlands

Salyut/Cosmos Docking

Sir, Could you clear up an apparent discrepancy with regard to which Salyut 6 docking port the Cosmos 1267 module was attached to? In Satellite Digest 148 (*Spaceflight* October 1981, p.274, note 14) it states that it was the rear port, while in P.S. Clark's article on "The Soviet Space Year of 1982" (*JBIS* June 1983, p.250) it is given as being the front port. Also, which Salyut 7 docking port did Cosmos 1443 use?

Also please find enclosed a contribution towards your Development Appeal. The excellent work which the Society does in promoting and nurturing interest in space deserves all the help it can get.

ALASTAIR NICOL
Aberdeen

P.S. Clark replies:

The Soviets never said at which end of Salyut 6 they had docked Cosmos 1267, but this can be deduced. The first clue is that the Soyuz T-4 crew altered the front docking unit of Salyut before they left the station, at which time Cosmos 1267 was in orbit. The second clue came with the de-orbiting of the Salyut/Cosmos complex. As I pointed out in "The Soviet Space Year of 1982," the de-orbiting was in two parts: the first was the lowering of the complex's orbit using Salyut 6's propulsion system and the second was the final de-orbiting using Cosmos 1267. The only way that Salyut could have used its propulsion system for the manoeuvre would have been if the rear docking port were free, which immediately places Cosmos 1267 at the front. To my knowledge, a Salyut has never used its propulsion system when the rear docking unit has been occupied. Now, turning to Salyut 7/Cosmos 1443. The pictures of the Soyuz T-9 docking clearly showed it to be docking at the back of Salyut, therefore Cosmos 1443 had to be at the front. This has been borne out by the undocking of Cosmos 1443 followed by the Soviet-announced redocking of Soyuz T-9 at the front.

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

Women Astronauts

Sir, Could you tell me if there are plans to launch an all-women Shuttle crew in the future? NASA now has eight women astronauts — more than enough for a full crew.

D.E. WATSON
Bristol

There are eight US women astronauts but none of them are pilot qualified. All eight are Mission Specialists which means they do not pilot the Orbiter but take care of orbital operations such as satellite deployment or EVA work. It could be that a female pilot will be selected from the most recent applications but there would be no scientific value in flying an all-female crew. At the moment, no crews have been put together with more than one woman included. The Mission Specialists are selected for a particular mission depending on that mission's requirements; for example, some astronauts have concentrated on satellites carrying the PAM boost stages, while others have dealt with the IUS stage or using the Shuttle's robot arm.

The first six US women astronauts. From top: Kathryn Sullivan, Anna Fisher, Rhea Seddon, Sally Ride, Shannon Lucid and Judith Resnik.

SOCIETY NEWS

MORE PUBLICITY

Press

Engineering for January 1983 contained an extremely interesting article called "Making it in Space" which not only credited the Society but gave its full address. *Design* for December included a write-up of the Brighton Conference.

An even more unlikely candidate was *Spotlight* magazine for January, 1983 which is mainly concerned with holidays but which, nonetheless, included a page devoted to "Daedalus."

Newspaper-wise proved even more far-flung. An item in the *Evening News* of Daytona Beach, Florida, recorded the election to Fellowship of the Society of Bob Havilland, while the *Weekend Post* from South Africa contained a nice piece about our forthcoming trip to that country to witness the return of Halley's Comet in 1986. The *London Free Press* (not London UK but London, Ontario, Canada) contained a long report about the Brighton Conference, concentrating on the search for ET, while the German magazine *Star*, as a fine leg-pull, presented — as if fact — the idea the the British Interplanetary Society landed men on the Moon in 1944! It stated that papers had just come to light in the cellar of a house of one "DAH in Birmingham" and that secret practical experiments in space travel had taken place during the Second World War. It reported that the space ship *Brittania* (a nice touch, that) remained in lunar orbit after a three-day trip while the *Columbiade*, (a bit foreign-sounding for a UK spaceship) had landed on the surface. The story was supported by "photographs" — actually paintings based on the BIS designs and by an undoubtedly early-vintage David Hardy painting. An updated project, Daedalus, appeared in quite a different way in the *Scottish Daily Record* last May. This featured an astronaut of the future, Lance Maclean. Excerpts from the series dealt specifically with the BIS Daedalus probe proposed "over 100 years ago." It also mentioned three starships "Faith," "Hope" and "Charity," all of which must have guided the early designers. Since the cartoon didn't add "the greatest of these was Charity" — one must assume that Faith and Hope must have been particularly well-placed in the minds of the long-gone Daedalus team. As the *Glasgow Herald*, too, ran a piece about Daedalus, the reverberations are, clearly, continuing.

Books

Not many books on space appear to have been published of late, hence the dearth of the Society mentions in them. A new book by Tim Furniss, *Manned Space Flight Log*, did us proud: it not only referred to the Society prominently but gave our address and was all we could wish for. A book for young people by H.M. Mama, *Man in Space*, published in Bombay also mentioned the Society. To make up for this, the hero of a recent novel by Joe Poyer, *Vengeance 10*, is depicted as "A founder member of the BIS!"

To these authors we extend our thanks.

Displays

Although we send out bundles of magazines at every opportunity there is not usually much feed-back, though William Ganoe made good use of our material during the organisation of a Space Week in Tucson, Arizona.

A problem with displays is that there is always a requirement for tailor-made eye-catching boards, notices, etc. These need to be prepared on the spot, for setting out the magazines alone e.g. on a table, does not maximise their appeal. The specially-made display material is often bulky and doesn't stand up well to transit elsewhere.

Radio and TV

Howard Ilett, who provides a monthly astronomy chat on Radio Victory, was able to refer to the work of the Society on several occasions but radio and TV coverage planned for the Space '82 event was overshadowed by another news story which broke and which involved special programmes, with a result that many of the planned interviews did not go ahead. However, Arthur Clarke gave us a good plug on breakfast TV on 15 May, during which he mentioned our 50th Anniversary, while the BBC External Services produced a host of programmes on the topic, with Andy Wilson appearing frequently. Mat Irvine gave us a plug last November, mentioning *High Road to the Moon* on BBC while wearing his BIS sweatshirt and showing a model of the BIS Lunar Lander for the first time. However, a little wishful thinking was shown in the TV Times advertisg was shown in the TV Times advertising Mat's appearance. It ran: "Today Fred looks at the plans of Daedalus, a British-designed star ship that *will* be launched next century"!

VOICE FROM THE PAST

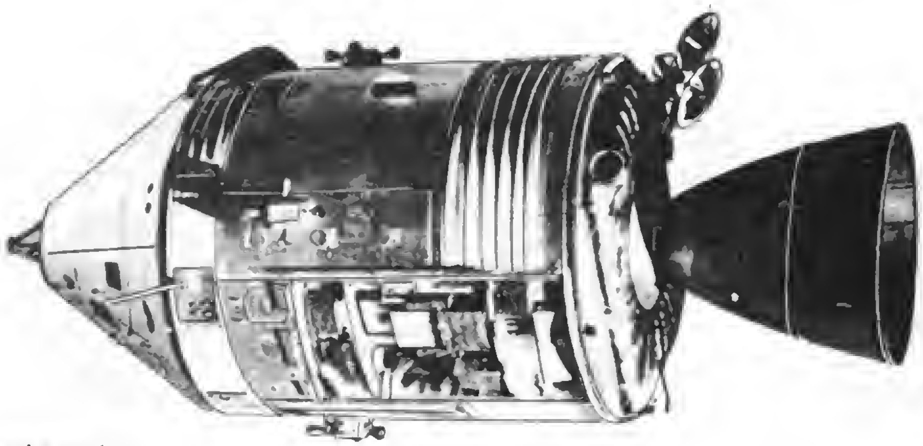
We were delighted to welcome to HQ recently Julian Rogers, now Assistant Project Manager for the Sentry Data Processing Project conducted by TRW.

Sixteen years ago, the first intimation of Julian's arrival was a telephone call from Dover stating that the Spacemobile which he had driven from Austria for use by the Society had been intercepted by the Customs who wanted a deposit of $4,000. Julian had to kick his heels while long-distance telephone calls took place between HQ and Dover to raise the cash at short notice so that he could make his getaway.

This bombshell was only the first of many to arrive in quick succession. First was one of finding a base for the Spacemobile, with its valuable contents, the second was finding a venue where training sessions could take place (using gunpowder and other combustibles) and, in no time at all, requirements for supplies of liquid oxygen, 100% alcohol and tins of gunpowder. Fortunately, all were solved in equally rapid succession by help from British Oxygen, from the whisky manufacturers James Buchan, who secured special Customs clearance to allow us to get access to a bonded store, and from the Police Commissioner who gave us permission to purchase gunpowder.

The next problem was rounding up a BIS lecture team for training. More help came, this time from both industry and the RAF. Shortly afterwards, to Julian's intense relief, the Spacemobile set out on its 3½ months spectacular tour, often giving shows at three different venues each day throughout the country.

Those who took part in the trips learned a lot, as was apparent from the subsequent report which appeared in *Spaceflight* of November, though there was nothing equivalent to Julian's own story of arrival at one school to find it had burned down overnight. There was nothing left but a pile of ashes. Far from giving up, the Spacemobile show went ahead exactly as planned, though this time in the local Courtroom with Julian sitting on the Judge's Bench!



SPACE REPORT

A monthly review of space news and events

ASTRONAUT TRULY RETIRES

Astronaut Dick Truly, pilot of Shuttle mission 2 in November 1981 and commander of flight eight in the summer of 1983, has retired from the astronaut ranks to take up the command of the "Naval Space Command" in Virginia. The new agency will direct the US Navy's space-related programmes.

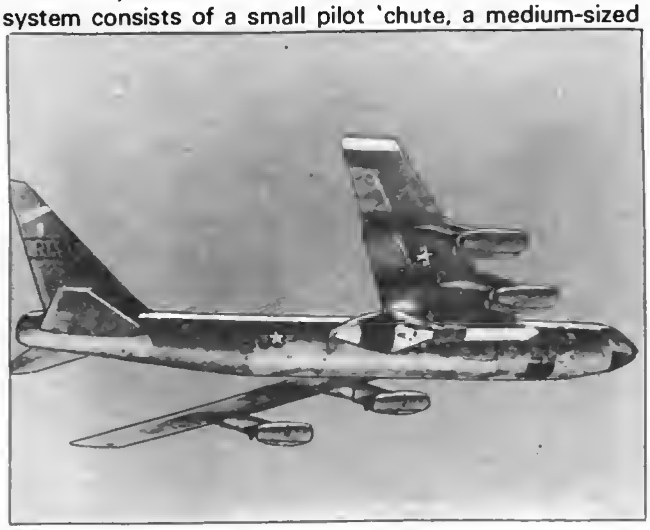
Truly became a military astronaut in 1965 as part of the US Air Force Manned Orbiting Laboratory project, transferring to NASA in 1969 when MOL was cancelled. He took part in the Shuttle *Enterprise* drop-tests in 1977 and made his first space flight aboard Shuttle *Columbia* with Joe Engle.

SHUTTLE PARACHUTE TESTS

A series of three "drop tests" to test larger parachutes for the Shuttle's boosters began in late September in California with a successful flight. Larger 'chutes will reduce the boosters' water impact and resulting damage.

Attempts earlier in 1983 to begin the tests, which involve dropping a mock booster from NASA's B-52 aircraft, were cancelled because of bad weather and mechanical difficulties.

The B-52 flew the mock booster to the China Lake Naval Weapons Center, where it was dropped over a special test range. The parachutes were triggered to deploy at a designated speed and altitude, testing their performance and load-carrying capability. In present Shuttle operations, a booster's standard parachute system consists of a small pilot 'chute, a medium-sized



drogue and three main 'chutes, 35 m in diameter. The new system will be made up of the standard parachutes but will use 41 m main 'chutes. Since the mock booster weighs about one-third of a real booster, tests are usng just one main 'chute.

NEW UPPER STAGE

Two US companies plan to build a new liquid-propellant upper stage for Shuttle work on a commercial basis. Ford Aerospace and Aerojet TechSystems will begin work on the Transtar engine in January for its initial use in the first company's Fordsat commercial communications satellite in about 1987, when it will be able to deliver 1400 kg to geostationery orbit.

Underloading the propellants would satisfy 730 kg satellites — competing with McDonnell-Douglas' PAM D-2 solid propellant upper stage — and a later version could handle 2900 kg to geostationary orbit, competing with IUS. The design at present is not compatible with other Shuttle payloads; the companies may need to make changes to satisfy NASA's requirements.

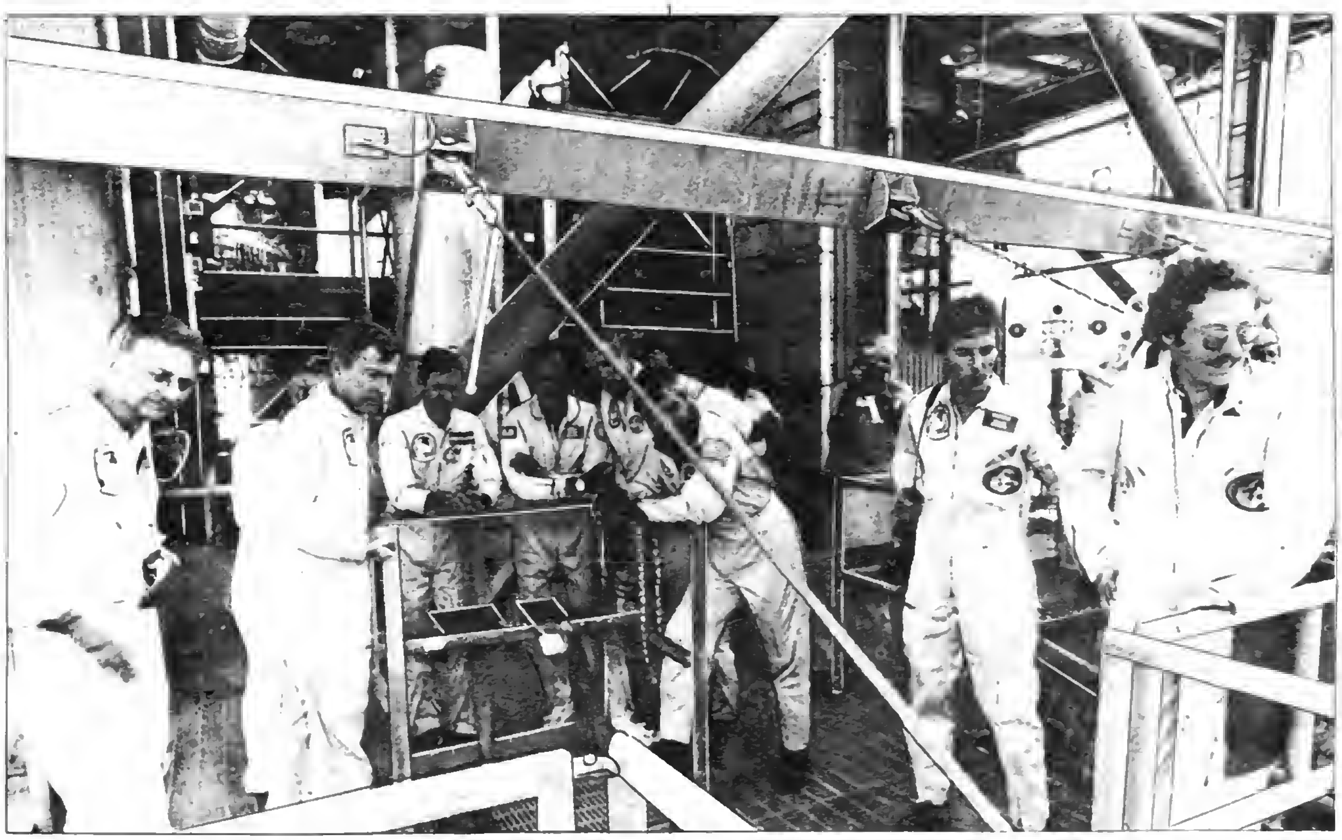
Several companies are now working on new upper stages. Orbital Systems Corp. are about to embark on a stage to handle 2730-6000 kg as from 1986 and Boeing may still decide to enter the market.

SHUTTLE TILES DELAY

One of the factors that resulted in the late first launch of the Space Shuttle in April 1981 was the time required to bond the 31,000 thermal protection tiles on to Orbiter *Columbia*. The problem arose again more recently — in a different form — with the completion of the third Orbiter, *Discovery*. Rockwell in California had been aiming for a delivery to NASA in early October last but the extensive use of new thermal blanket material, instead of the heavier white tiles, forced a two week delay.

Discovery carries only some 24,000 thermal tiles, (mostly the high temperature black version), as opposed to 29,000 for *Challenger*, and 31,000 for *Columbia*. The other areas are largely covered with the flexible blanket material first flown on STS-6 in April 1983. Both *Discovery* and *Atlantis* will carry thicker thermal protection on their upper surfaces because their launches into polar orbits from California will cause greater heating than in Florida missions. *Atlantis*, the fourth Orbiter, is being assembled now and is scheduled for delivery to NASA next December.

Above: The STS-11 crew take a break during their fire and emergency training. From left: Bruce McCandless (Mission Specialist), Bob Stewart (MS), Ron McNair (MS), Vance Brand (Commander) and Bob Gibson (Pilot). Of the five,only Brand has flown in space before – he was Commander of the STS-5 mission in November 1981. McCandless and Stewart will test the Manned Manoeuvering Unit that will be used during the STS-13 flight to rescue the ailing Solar Maximum Mission Satellite. Below: Like all other Shuttle crews, the STS-9/Spacelab 1 crew had to practice their emergency escape techniques. Here the crew and their backups watch a large cage which would whisk them away to safety from the launch tower. From left to right, the astronauts are: Owen Garriott (Mission Specialist), John Young (Commander), Brewster Shaw (Pilot), Wubbo Ockels (Backup Payload Specialist, ESA), Byron Lichtenberg (PS, USA), Bob Parker (MS), Ulf Merbold (PS, ESA) and Ken Lampton (Backup PS, USA). NASA



SPACELAB DELAY

Analysis of the recovered Solid Rocket Boosters used in the STS-8 Shuttle launched on 30 August 1983 has shown that insulation material in the rocket nozzles was almost completely worn away. A normal launch should reduce the 7.5 cm thick material to about half; the eigth mission had almost no protection remaining. The result might have been fatal — the boosters' exhaust could have burst through the side of the nozzle and sent the whole craft into a tumble.

A ground test on a booster on 11 October showed a similar problem. At the time of writing, the Shuttle has been taken off the pad. Since some of Spacelab's astronomical experiments require specific lighting conditions in space that could mean postponement until 27 November or late Feb 1984. (Launch subsequently fixed for 28 Nov – Ed.).

TRANSIT MODIFICATIONS

The US Navy are spending almost $10 million modifying eight of their Transit navigation satellites so that they can be launched two at a time by Scout rockets.

The SOOS (Stacked Oscar on Scout) project will begin to orbit the satellites in 1985, storing them in space for later use. Fifteen Transits were built for the US Navy in the 1970's. They had a design life of two years, but after the first three were launched it was discovered that they greatly exceeded that target. The other 12 are in storage.

Known as the Navsat programme, the satellites provide accurate position fixes anywhere in the world, day or night in any weather. The system has been expanded to provide navigation service for thousands of commercial ships equipped with receivers.

CANADIAN ASTRONAUTS

When Shuttle mission 31 lifts off on 26 November 1985 one of the crewmen will be a Canadian ready to test a more advanced control system for the spacecraft's Canadian-built Remote Manipulator System. A later mission will involve another Canadian in life sciences experiments concentrating on the body's response to weightlessness.

These two flights will come a step nearer this December when six Payload Specialist candidates are named, the survivors of 4100 applicants to the National Research Council of Canada. The option is still open for one or two of the group to go forward as Mission Specialist candidates, becoming permanent additions to the astronaut corps. A Payload Specialist trains for a specific experiment whereas an MS is available for any flight.

NEW ARIANE PAYLOAD

Arianespace, the company marketing the European Ariane rocket, has captured another contract for a US communications satellite launch. GET Spacenet have signed a $25 million contract for the launch of their 1200 kg Spacenet 3 satellite in early 1985. The two earlier satellites are already scheduled on Ariane for 1984.

The Ariane L7 launch, originally set for 15 September, had to be delayed because Intelsat wanted to check their payload after noise was detected in transmissions from the Intelsat V-F5 satellite already in orbit.

Mrs. Thatcher, with Erik Quistgaard, visits ESTEC.

PREMIER'S ESTEC VISIT

UK Prime Minister Mrs. Thatcher visited the European Space Agency's Research and Technology Centre (ESTEC) at Noordwijk in the Netherlands on 19 September in the company of ESA's Director General, Erik Quistgaard, and its Technical Director (who is also ESTEC's Director), Professor Massimo Trella.

ESTEC is ESA's largest establishment, with a multinational staff of almost 800. Most of ESA's project teams working on the design and development of satellites are located at ESTEC. At the height of the Spacelab development phase, a team of about 100 engineers were working on that programme alone, and a permanent team of about 300 carry out technological research, development studies and testing in support of all ESA programmes. ESA's Space Science department, with some 30 highly specialised scientists, is also housed at ESTEC.

X-RAY OBSERVATORY

NASA has released an "Announcement of Opportunity" to invite scientists around the world to propose telescopic instruments for a planned future X-ray observatory in space. Known as the Advanced X-ray Astrophysics Facility, or "AXAF," this orbiting telescope could be launched by the early 1990's.

"The scientists will probably have a large number of suggestions of ways to study the X-rays," said Carroll Dailey, the Marshall Center's study manager for the advanced observatory. "For example, a high-resolution camera, one that gives very sharp and detailed images, might be proposed. Or a low-resolution camera — which wouldn't give as much detail but would have a wider field of view."

"Other ideas might include high and low resolution spectroscopy instruments, which would study the spectrum of the X-rays much as we now study the spectrum of visible light. The scientists may even propose polarimetry devices, which would study polarized X-rays. In other words, there's a wide range of suggestions the scientists may send to us."

The proposed instruments will be screened by a group

of scientists, who will then recommend to NASA the instruments for possible integration into the observatory.

It will be the latest in a series of X-ray satellites dating back to the Uhuru satellite launched in 1970.

The advanced facility, weighing about 10 tonnes and measuring 14 by 13 m, would provide a substantial leap in X-ray astronomy. It is the successor to HEAO 2, the second High Energy Astronomy Observatory launched in the 1970's. This obtained valuable data and discovered many previously undetected X-ray sources. The HEAO 2 results raised new scientific questions which AXAF, with up to 100 times the sensitivity, will possibly be able to answer.

SPACE PLATFORM

The Fairchild Space Co. have agreed with NASA to build a $200 M space platform under a Joint Endeavor Agreement by which two Shuttle flights will be made available free of charge. The 5500 kg "Leasecraft" will eventually be hired out to customers, such as remote sensing or materials processing companies, for carrying their payloads in orbit at $3 M to $5 M per month.

Each Leasecraft will be repaired or refuelled in orbit by the Shuttle; half of the platform's mass will be propellant for moving around the normal 520 km orbit. The design will allow the satellites to be serviced from a space station, at the same time providing a more mobile platform than a manned station.

The two free Shuttle flights are worth about $50 M each at present values — the first will deploy the initial Leasecraft in 1987 and the second will service it 6 months later.

INTELSAT VI LAUNCH DECISION

Intelsat is delaying its choice of launch vehicle for three of its Intelsat VI communications satellites. Intelsat has on order a total of five Intelsat VIs, each of which will weigh about 4,000 kg and have a basic capacity equivalent to more than 30,000 simultaneous telephone calls. They are scheduled for launch from 1986 onward.

Last June, Intelsat decided to launch the first two of the new series using the Shuttle. At the moment, the choice for the other three will be between the Shuttle and the European Ariane 4 rocket, although Intelsat was waiting for a bid from Martin-Marietta for Titan 34D launch services in November.

Studies are also underway on the possibility of launching two Intelsat VIs aboard one Shuttle flight.

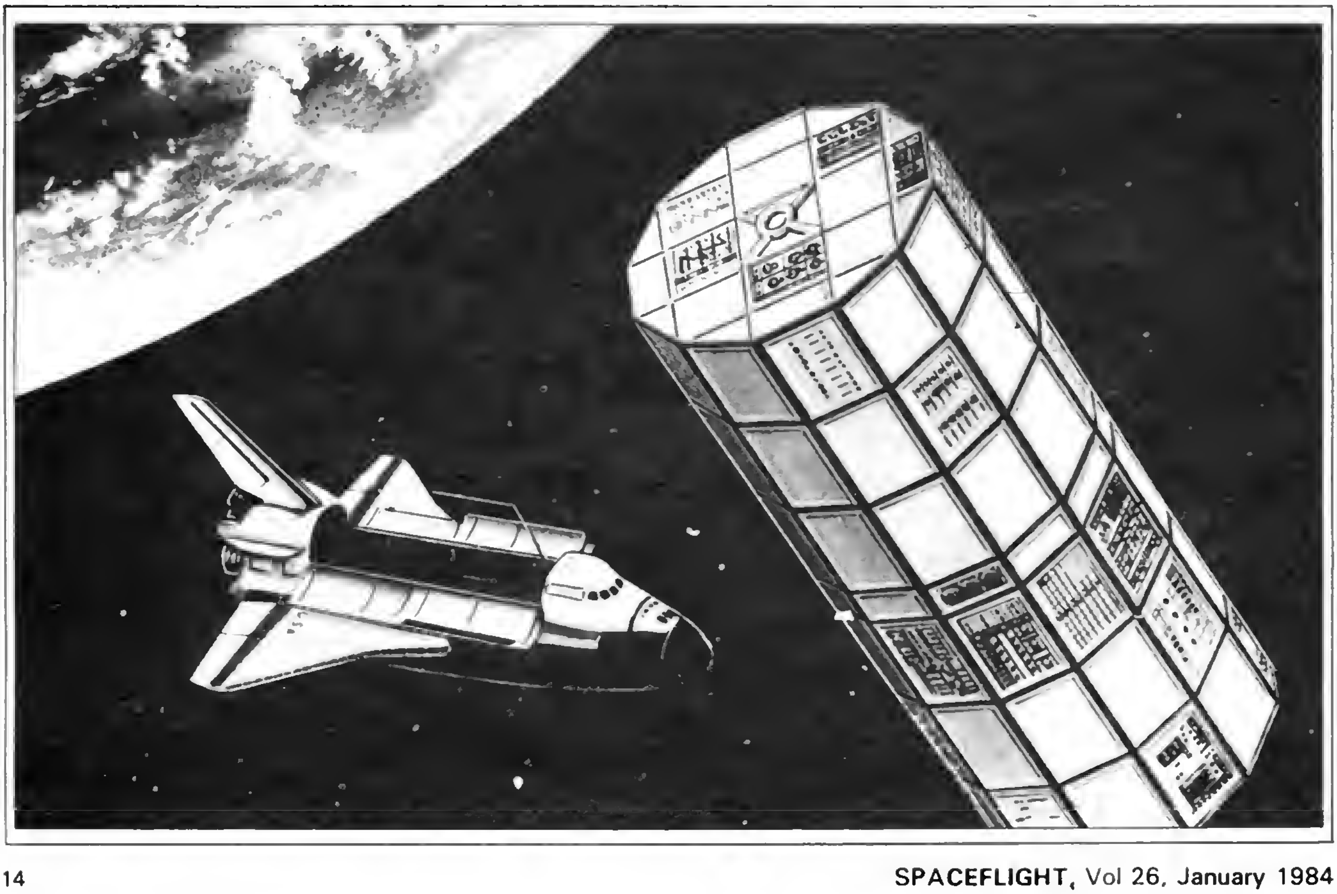
SOLAR MAXIMUM REPAIR

Scientists have successfully reactivated an experiment switched off more than two years ago when the Solar Maximum Mission (SMM) satellite lost the use of its attitude control system.

The team spent more than a week testing, through radio commands, two spectrometers of the X-Ray Polychromator. Successful operation of this experiment is a vital milestone in preparation for the Shuttle repair mission next April. Those repairs will fully restore the SMM's fine-pointing capabilities.

SMM operated for over 9 months and observed some 300 solar flares before the attitude control failure. Fortunately, many other instruments did not have the same

The STS-13 flight in April will carry NASA's Long Duration Exposure Facility (LDEF) into orbit for deployment with the Shuttle's robot arm. The LDEF, 4.3 m in diameter and 9.1 m long, is designed to provide low-cost orbiting facilities for experiments and applications, such as materials processing work, which require long periods in space but which do not warrant their own, expensive, satellites. STS-13 will leave this first LDEF in orbit for STS--22 to retrieve in February 1985. Since the experiments are all designed to be self-contained (as are the Getaway Special canisters already flown on the Shuttle) the LDEF itself can be reused. The first model arrived at the Cape last summer for integration into Orbiter *Challenger* for STS-13. *NASA*



accurate pointing needs and have continued to relay data. Solar flares occur where there is a strong concentration of the Sun's magnetic field. Sun spots, relatively cool regions on the Sun's surface, occur at the same locations, but the relation of the spots to flares is not entirely understood.

The X-rays studied by the two spectrometers, one for split second observations and the other for excellent spatial resolution, are produced by the Sun in the extremely hot, energetic flare process and reveal clues as to what is happening.

In some, as yet unexplained, way flares may also effect the Earth's weather. But because the study of the Sun has always been limited by the Earth's obscuring atmosphere only limited data were available until the advent of the space age and the use of sounding rockets, satellites, and, notably, Skylab to observe the Sun from space.

ASTRONAUTS IN LONDON

Shuttle astronauts Sally Ride and Fred Hauck (both STS-7) visited London in mid-September, bringing with them a medal carried aboard Shuttle *Challenger* which was originally struck to commemorate the centenary of the epic voyage of *HMS Challenger*. Rear Admiral George Ritchie, a former Royal Navy hydrographer, asked NASA to carry the medal marking the 3½ year, 110,000 km voyage of the first modern oceanographic survey ship. Dr. Ride returned the medal during a visit to the old War Office in Whitehall.

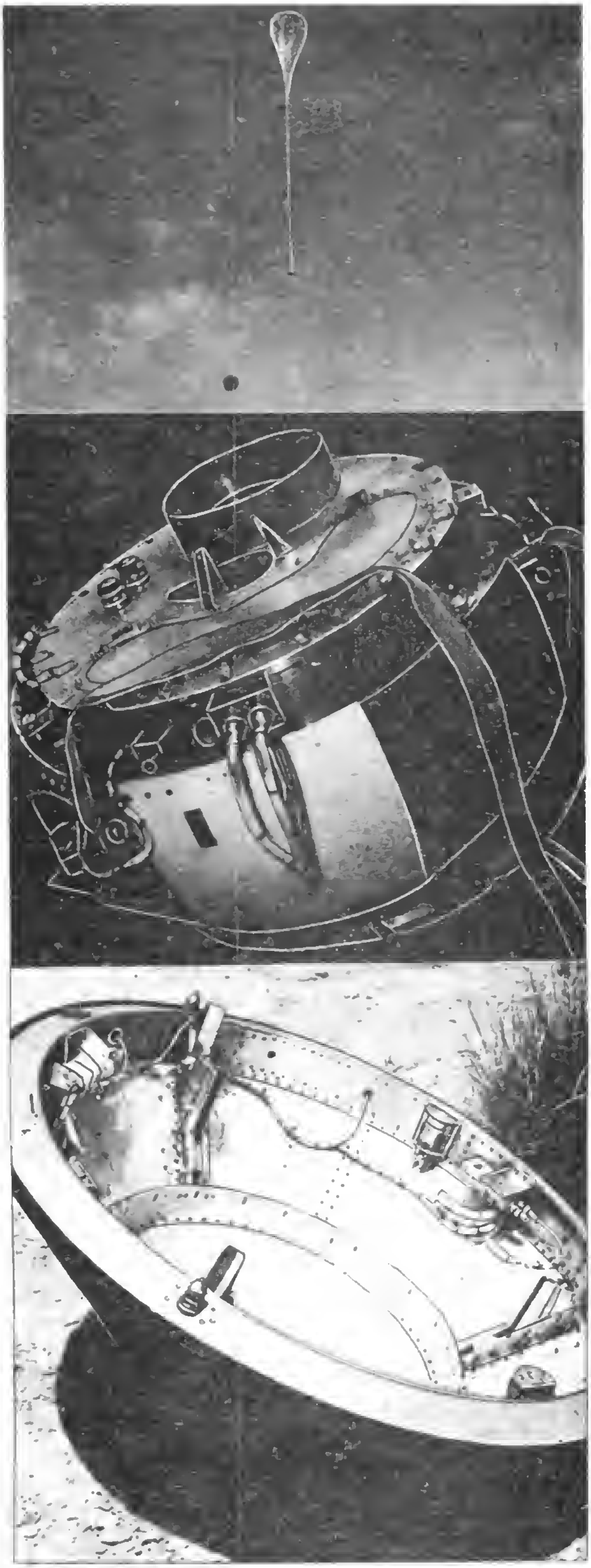
At a press conference held in the US Embassy earlier that day, *Spaceflight* editor Andrew Wilson asked the first US woman astronaut if she had yet been selected for another flight. "Not yet," she replied, "but I hope to fly again in about a year." Fred Hauck has already been picked to command the STS-16 mission next year.

Capt. Hauck revealed that all the astronauts underwent testing in a rotating chair to check their susceptibilites to motion sickness — space sickness is still something of a mystery although Dr. Bill Thornton on the STS-8 mission thought that the problem was solvable. Anti-sickness pills are available but pilot Hauck — a naval officer — does not suffer from either space or seasickness. "Besides," he pointed out," space sickness does not stop the sufferer from working effectively. Seasickness is much more severe."

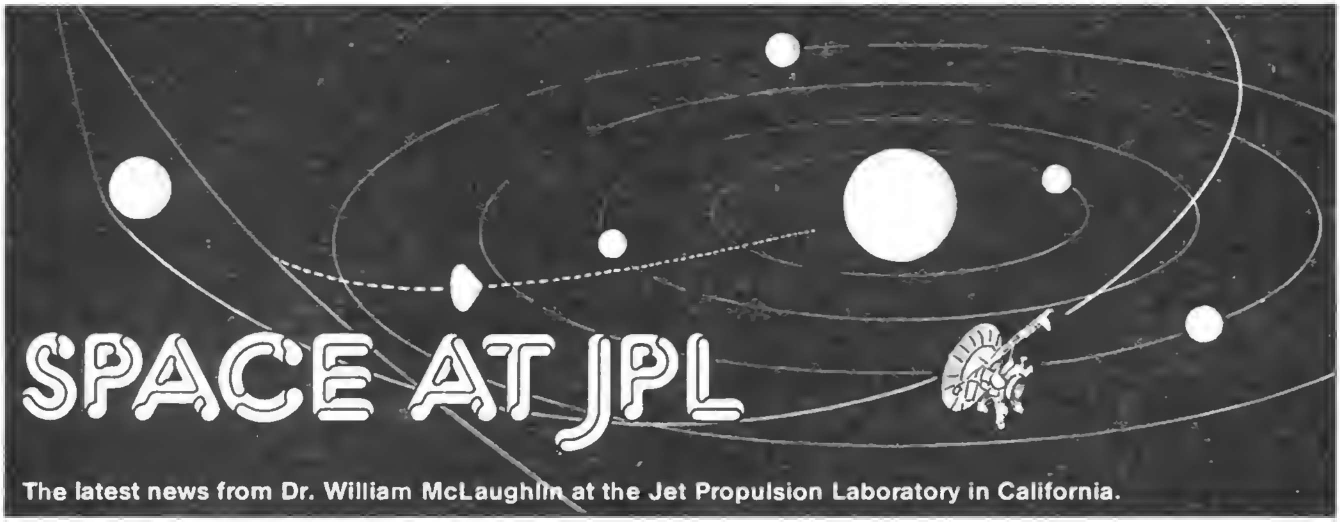
The astronatus believed that discussions were continuing with the British Government for a UK astronaut to fly aboard the Shuttle with a military Skynet communications satellite. Responding to another question, Capt. Hauck said that he did not know of any plans to arm the Shuttle against offensive satellites.

The Society's President, Tony Lawton, and Executive Secretary Len Cater were among the guests at a Reception put on by the American Ambassador, His Excellency John L. Louis, to honour the astronauts later the same day. Several other BIS stalwarts figured among the guests, including Dr. John Becklake (former BIS Council member), Mr & Mrs. Reg Turnill and Dr. Desmond King-Hele (RAE Space Department).

Reg Turnill freely dispensed good advice for potentially long-winded speakers at Society functions which ran, "Stand up, Speak up, and Shut up!" while Desmond King-Hele, figuratively speaking, espoused his studies of the Earth's gravity field by pointing out, incidentally, that the shape of the Earth (geoid) was known to 10 m 20 years ago and now it is down to 1 m. His view of the Shape of Things to Come included the thought it might be down to less than 10 cm 20 years hence.



As noted on p. 442 of last month's "Space Report," the atmospheric probe of the Galileo Jupiter spacecraft was successfully drop tested during the summer by NASA's Ames Research Center. The probe was lifted 30 km high by a balloon and released to test the parachute deployment and heathsield separation sequences. The test simulated aerodynamic conditions expected in the upper layers of Jupiter's atmosphere when the probe reaches the giant planet in late 1988. As seen above, the probe model was successfully recovered after the New Mexico test; the real probe will be destroyed after relaying data on Jupiter's atmosphere to the orbiter portion of Galileo. The separated heatshield is seen in the bottom frame. *NASA*



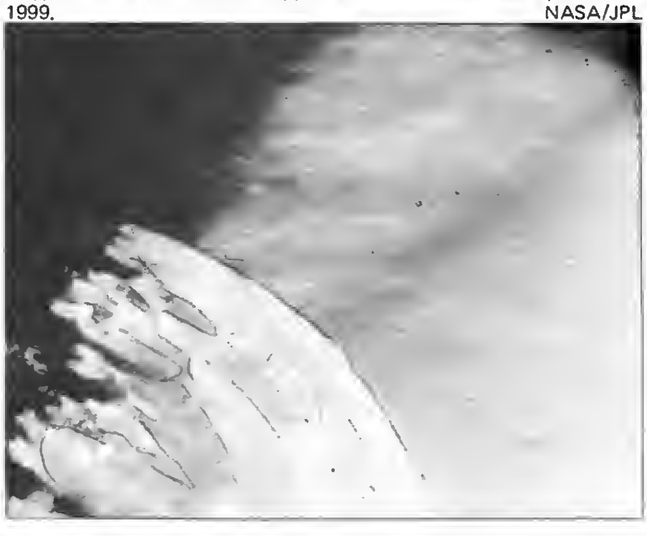
MISSIONS TO PLUTO

Since the introduction in last April's issue of a monthly review of an advanced-concept mission, we have looked at new ways to explore the Moon, Mars, Saturn and Neptune. This month features three (unfunded) options to explore the distant iceball, Pluto.

Pluto was discovered in 1930 by Clyde Tombaugh as part of Percival Lowell's long-term search for a trans-Neptunian planet. Its satellite, Charon, was discovered in 1978 by R.S. Harrington, and observation of the motion of this binary system has resulted in a reasonably accurate determination of Pluto's mass. The planet has about the same density as water: 1 g/cc.

The first mission option is of historical interest only; Pluto was originally included in planning for the Grand Tours of the outer planets to be launched in the late 1970's. One mission concept would have employed four spacecraft with two being launched in 1976/1977 to survey Jupiter-Saturn-Pluto and the other two launched in 1979 to flyby Jupiter-Uranus-Neptune. The $750 million required for this project was judged to be too great an expenditure, and the more economical Mariner Jupiter/Saturn project was created in 1972. Renamed "Voyager," the two spacecraft launched in 1977 have revolutionised our understanding of Jupiter and Saturn, with plans to visit Uranus (1986) and Neptune (1989) by Voyager 2. However, Pluto had to be dropped from the timetable of outer-planet exploration.

In this artist's concept, the satellite Charon is seen in the foreground by a hypothetical spacecraft as it approaches the Pluto-Charon system in 1999. NASA/JPL



The key to a reasonably short flight time for a ballistic mission to Pluto (i.e. one not using continuous thrust as in nuclear or solar electric propulsion) is a gravity assist by Jupiter. Without such an assist, a ballistic flight to Pluto could last about 30 years. Since Pluto orbits the Sun very slowly with its 248 year period and Jupiter circles the Sun every 12 years, it can be expected that Pluto-Jupiter-Earth line up favourably for a gravity assist about every 12 years. Thus, the favourable alignment of the two planets in the late 1970's, when the Grand Tour was envisaged, will recur in the late 1980's to early 1990's.

R.A. Wallace, A.L. Lane, P.H. Roberts and G.C. Snyder of JPL have examined this period for missions to the outer planets, including Pluto, and have identified many interesting flight possibilities. We will review one such scenario.

After a 1989 launch Pluto would be encountered by the 800 kg spacecraft after 10 years of flight, having been boosted by a combination of chemical thrusting and gravity assists by Earth (re-encountered 2.2 years after launch after looping out in space in a so-called delta Vega trajectory) and Jupiter. Imaging resolution of the planet would be 677 km at 24 days before encounter and would improve to 169 km at six days before encounter. Imaging of Charon would begin three days before encounter. Just 7 hours prior to encounter imaging mosaics would be laid down on Pluto, with similar coverage of Charon begun at encounter minus 3 hours. During the rapid, 18 km/sec ride through the system, the spacecraft would experience occultation as viewed from Earth by both Pluto and Charon, providing information on their sizes. In order to send back all of the information gathered during the encounter, it may be necessary to provide a large, on-board data storage capability and then gradually return the information after encounter at the leisurely rate enforced by the great separation from Earth.

The third exploration option to be considered for Pluto returns to the theme of the first: Pluto as an add-on to the main mission. L.D. Jaffe and C.V. Ivie of JPL have described an interstellar precursor mission designed to explore very deep space but not actually flyby a star (see *Icarus* **39**, pp.486-494, 1979). The spacecraft would be launched with a great speed, escaping from the Solar System at approximately 100 km/sec, and would be directed along the line of the Sun's motion in the Galaxy so as to cross the heliopause as soon as possible. The heliopause is 100 to 150 astronomical units (AU) from the Sun (Pluto is 40 AU distant) and is the place where the outgoing solar wind is turned back by the oncoming

flow of the interstellar medium. If this mission were launched somewhat near to the year 2000, it turns out that Pluto would lie very near to the probe's trajectory as it shot outward. Jaffe and Ivie suggest carrying a television camera and infrared and ultraviolet sensors with which to study Pluto. A variant to this mission would carry a daughter spacecraft along with the deep space probe and drop it off at Pluto to go into orbit about that planet. For this case, the authors suggest the addition of a gamma-ray spectrometer and an altimeter to the payload.

MISSION PLANNING FOR IRAS

A flood of discoveries by the infrared Astronomical Satellite (IRAS) in astrophysical and Solar System astronomy as occurred since its launch in January 1982. Exciting as these discoveries are, they overlay the primary purpose of IRAS: the completion of a systematic survey of the entire sky for infrared sources. The sky-survey data is now being reduced at JPL, and later this year a catalogue of perhaps a quarter of a million sources will be issued.

The catalogue will provide a data base for generations of astronomers who will be using spaceborne and Earth-based instruments to examine in detail objects recorded by IRAS. Historically, catalogues and atlases have played a significant role in astronomical research from Hipparchus's work in the second century B.C. though Argelander's great nineteenth century catalogue (years in the making, with 324,000 stars observed by eye at the telescope!) and the fruitful Palomar/National Geographic photographic survey of 30 years ago.

The strategy for the IRAS survey was carefully designed by the international team (US, Dutch, UK) before launch in order to reduce the interference of the Earth's radiation belts and infrared glow from Sun, Moon and Earth. However, this survey, composed of more than 5000 scans, could not be designed without allowing for new mission planning after launch. A detailed summary of the contributions of all elements of the IRAS team can be found in the reprints of papers from the special IRAS session at the AIAA's 22nd Aerospace Sciences Meeting in Reno, Nevada.

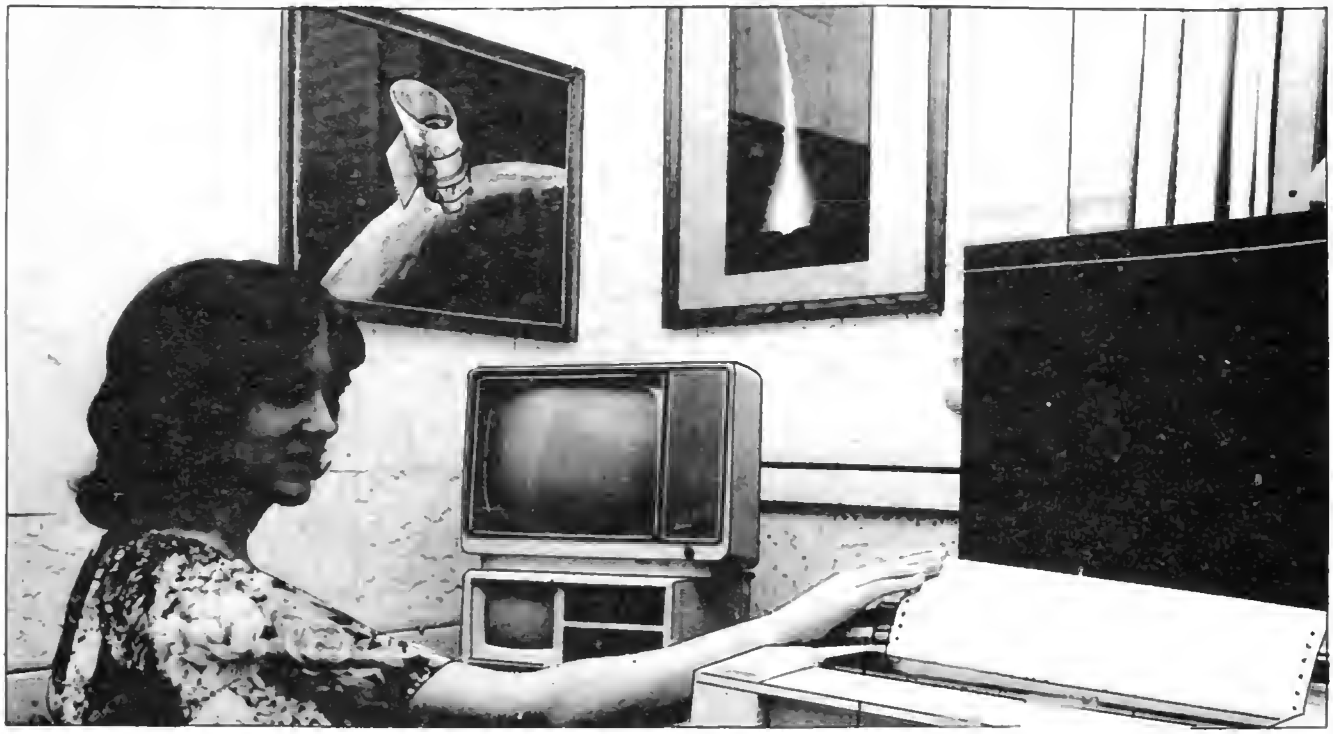
Mission planning after launch at JPL was done by the Survey Planning and Analysis (SPA) team, headed by Sylvia Lundy. Information transfer between SPA and the Operations Control Center (OCC) at Chilton in England was helped by meetings at the OCC about every two months during operations and, on a daily basis, electronic data transfer between the American Univac 1100 computer and the British ICL 2960 machine. Special arrangements were made to automatically plot in England sky-coverage maps produced on the Univac.

I discussed with Lundy some of the challenges which she and her team faced in the course of successfully completing the all-sky survey. "Basically, the prelaunch plan was validated by our actual experience in operations, but we never felt that everything was routine: we just kept hoping that it would become so."

She explained that the period immediately after launch was one of relatively high solar activity and correspondingly high activity in the Van Allen radiation belts, which made observing more difficult. Then in early June tha satellite experienced problems that kept it from taking data for three days. Throughout the sky survey, individual scans failed to occur for a variety of reasons, and these failures had to be recorded for subsequent makeup purposes. In order to keep in close contact with the control centre in England from JPL during periods of high activity the SPA team supplemented computer connections with the old-fashioned telephone call: well over 100 times during the main survey period from February to August. The time difference of eight hours between the US and England made the scheduling of calls a problem!

On 26 August the first survey of the sky was completed and Lundy said she felt "excited and relieved" when the satellite had finished its task of surveying each point of sky four times. Immediately a second survey was begun, to observe each point of sky twice more in order to increase the completeness and reliability of the catalogue. Lundy summarised the general feeling in the project when she said, "before launch we didn't know if we would be lucky enough to get this far," referring to the fact that prelaunch predictions of the IRAS lifetime (determined by

From a work station at JPL Sylvia Lundy is able to communicate directly with the IRAS Operations Control Centre in Chilton, England.



how long the liquid helium coolant would hold out) were only about 220 days. In flight, the boil-off of helium used to cool the sensitive detectors was 40% slower less than predicted.

TABLE MOUNTAIN OBSERVATORY

A few hours drive northeast of JPL, near the town of Wrightwood in California, lies the Table Mountain Observatory. This astronomical facility is owned and operated by JPL in support of its work for NASA.

The observatory was established by the Smithsonian Institution in the 1920's as part of its long-term programme of solar observation and was first used by JPL in the 1950's for calibration and testing of solar panels and other spacecraft hardware. The present optical equipment consits of 16-inch and 24-inch reflecting telescopes with a 40-inch reflector under construction, in conjunction with Pomona College.

Considering the very large telescopes now in existence at various locations around the world, and the even larger ones that are being planned, the size of the relatively modest equipment at Table Mountain might be questioned. Of course, size alone is not the only factor that determines the value of a telescope; the 24-inch IRAS telescope has profoundly modified our view of the Universe. A third factor, in addition to size and favourable location, is availability. Very large telescopes are heavily booked and can only be used to a limited extent on any one project. There are some projects that need large amounts of data, to study time-varying phenomena, and do not require high resolution or large light grasps. Examples include measuring the time-varying brightness of asteroids, studying the changing sodium ion cloud about Jupiter's satelllite Io, and comet studies. Astronomer Ray Newburn, who was instrumental in the development of Table Mountain Observatory, has termed this type of astronomy "synoptic observing."

On a personal note, Table Mountain Observatory occupies a special place in my memories since, through its 16-inch telescope, I watched the last Apollo spacecraft return to Earth from its lunar visit, on a wintry night in 1972 (see "One Eye at the Telescope" in the January 1982 issue). The flickering, thirteenth magnitude point of light carrying three astronauts slid across the background of stars until it was lost among the trees on the mountain top.

A GIOTTO EXPERIMENT

The ESA Giotto mission to explore Comet Halley will be launched in 1985 to flyby the inner Solar System's most celebrated visitor as it reaches perihelion early in 1986. Although a US mission to Halley was never approved, American participation will come through involvement in Giotto's experiment teams. The participation of European scientists on NASA's Space Telescope project is a reciprocal example.

I spoke with Marcia Neugebauer, a space physicist at JPL and a co-investigator for the Ion Mass Spectrometer (IMS) on-board Giotto. The principal investigator of this 16-person team is Dr. Hans Balsiger of the University of Bern. IMS will measure the ionized component of the comet's coma. The coma is the gaseous 'head' that surrounds the small nucleus and is created by material boiled off from the nucleus as the Sun approaches. Some of the atoms and molecules of the coma become ionized in the process, most of the ions being created by the effect of solar photons. In order to understand the chemistry and particle dynamics of Comet Halley, it is essential to record the types of ions in and about the coma and to map out their interaction with the solar wind.

Resident astronomer Jim Young is seen at work at the 24-inch telescope at JPL's Table Mountain Observatory. R. House

For this purpose the IMS is split into two components: HIS and HERS. HIS is the High Intensity Spectrometer and is optimized for observations in the inner portion of the coma, while the High-Energy Range Spectrometer (HERS) is specialised for the outer part where the interaction with the solar wind is particularly important.

Neugebauer has been involved with the design of the HERS instrument and explained some of its characteristics. The ions, being electrically charged, are deflected by magnetic and electric fields in HERS, allowing us to deduce the trajectory and velocity of each observed ion, along with its mass-to-charge ratio. Thus, a rather complete picture of the flow of ions in the region of the outer coma is obtained, together with identification of the ions.

HERS is shielded from onrushing dust particles in order to avoid damaging impacts during this 70 km/s flyby. It uses an electrostatic mirror which can sample ions either in the direction of the solar wind or close to the spacecraft ram direction. The proof-of-concept model for HERS was built at JPL. The flight model is being built by the University of Bern, the Max Planck Institute of Aeronomy and the Lockheed Corporation. A technical description of IMS is available in ESA SP-169, June 1981, pp.93-98.

SHUTTLE SCHEDULE

The coming year should see a total of 11 Shuttle launches from the Kennedy Space Center in Florida, involving Orbiters *Challenger, Discovery* and *Columbia.* The list below provides a quick look at who and what will be flying on each mission; not all of the crews have been announced. It now appears that mission 12 will not fly at all in order to give engineers time to solve the Inertial Upper Stage problems encountered on STS-6. For the same reason, STS-10, which should have flown in November 1983 with a military payload, was cancelled altogether, leaving Mattingly's crew looking for a reassignment.

In the November issue's "Milestones" section it was noted that Orbiter *Columbia* was to be placed in storage for two years following the STS-9 mission because Rockwell, the builders, could not cope with its modifications programme at the same time as building the *Atlantis* Orbiter and the B-1 bomber aircraft. NASA Administrator James Beggs has now decided that storage would be a bad move politically and in engineering terms — *Columbia* will now be available for flights before its modifications to a fully operational craft. The most likely are missions 17 and 20. The schedule below is correct as of mid-September but new decisions before publication might result in changes.

NASA are now announcing missions without STS numbers because of the possibility of mission schedules changing (e.g. STS-13 will now fly before STS-12). Thus, STS-14 as listed here is now called "41-E", with the '4' designating a 1984 launch, the 1 indicating a Cape Launch (2 = Vandenberg in California); the 'E' showing it is the fifth scheduled for that fiscal year. At the time of writing it is not clear how the STS numbers of 1984's launches are affected; for clarity the old desingations are used here.

LATE NEWS: Since the table was prepared for publication the STS-12 mission has been cancelled because the Inertial Upper Stage will not be ready in time for a May launch. The payload and crew could switch to mission 15 in July, although that spot might be occupied by the cancelled STS-10 mission (also IUS). STS-18 will accommodate whichever is not allocated to 15. Payload Specialists Charles Walker (shown in the list under STS-12) may move to mission 14.

FLIGHT/ORBITER LAUNCH DURATION	**CREW**	**PAYLOAD**
STS-11 *Challenger* 29 Jan/8d	Brand, CDR, 2 Gibson, R.L., P McCandless, MS Stewart, MS McNair, MS	Palapa B-2 SPAS-01A Westar 6

Palapa-Westar are both communications satellites using PAM-D stages to reach geostationary orbits. SPAS is the W. German experimental platform first flown on STS-7. The Manned Manoeuvering Unit will be tested in preparation for the STS-13 SMM repair.

STS-13 *Challenger* 4 Apr/6d	Crippen, CDR, 2 Scobee, P Nelson, MS Hart, MS Van Hoften, MS	LDEF SMM repair

LDEF is NASA's Long Duration Exposure Facility which will be released carrying experiments and recovered by STS-22 in February 1985. The faulty Solar Maximum Mission satellite will be captured, repaired in the Orbiter's cargo bay and then released. Crippen will be the first man to fly the Shuttle three times.

STS-12 *Discovery* 7 May/7d	Hartsfield, CDR, 1 Coats, P Resnik, MS Hawley, MS Mullane, MS Walker, PS	TDRSS-B **CANCELLED:** See "Late News" Note Above.

TDRSS is NASA's Tracking and Data Relay Satellite using the Inertial Upper Stage. Charles Walker is a McDonnell-Douglas engineer who will operate the company's electrophoresis unit, aimed at producing purer pharmaceuticals. Judith Resnik will be the second US woman to fly.

STS-14 *Discovery* 4 June/7d	Bobko, CDR, 1 Williams, P Seddon, MS Hoffman, MS Griggs, MS	Telesat 1 Syncom 4-1 OAST 1 LFC 1

Telesat & Syncom are communications satellites bound for geostationary orbit. Syncom carries its own boost motor, Telesat will use a PAM-D. OAST is an office of Aeronautics & Space Technology package for operation from the payload by. LFC is the Large Format Camera, under test for mapping the Earth, etc. Bobko flew as pilot of STS-6; Seddon will be the second US woman to fly.

STS-15 *Discovery* 14 July/?d	Crew to be announced See "Late News" Note.	None yet

This is a reflight opportunity, possibly taking the military payload and crew dropped from STS-10.

STS-16 *Discovery* 5 Aug/6d	Hauck, CDR, 1 Walker, P Fisher, A.L., MS Allen, MS, 1 Gardner, MS, 1	Telstar 3C Syncom 4-2 SBS-D Spartan 1

Telstar, Syncom and SBS are all geostationary communications satellites. Spartan (Shuttle Pointed Automomous Research Toll for Astronomy) will carry X-ray telescopes for the US Naval Research Laboratory. Hauck flew as pilot of STS-7; Allen and Gardner were Mission Specialists on flights 5 and 8, respectively; Anna Fisher will be the third US woman to fly.

STS-17 *Discovery* 30 Aug/8d	Crew to be announced	ERBS OSTA-3

ERBS is the Earth Radiation Budget Satellite, to investigate the absorbtion and reradiation of solar radiation by the Earth. OSTA is a set of experiments by NASA's Office of Space and Terrestrial Applications.

STS-18 *Challenger* 29 Sept/7d	Crew to be announced	TDRSS-C Opportunity

TDRSS-C is the third of NASA's Tracking and Data Relay Satellites. There is space available for another payload.

STS-19 *Discovery* 24 Oct/6d	Crew to be announced	Arabsat A Telesat H Gas Bridge

CDR: Commander; P: Pilot; MS: Mission Specialist; PS: Payload Specialist; AFSE: Air Force Space Engineer. Number after crew position indicates number of previous missions.

The Latest Developments from
Cape Canaveral in Florida

By Gordon L. Harris

SHUTTLE PROCESSING CONTRACT

The most important news of the year for 6,000 contractor personnel processing Shuttles at KSC and Edwards came on 7 September when NASA selected an industry team headed by Lockheed to take over such work. The contract is worth $2000 million for the first six years and could run to $6000 million over 15 years. Joining Lockheed are Grumman, whose local president is ex-astronaut Fred Haise; Pan American World Airways and Morton Thiokol, the company which produces solid boosters for Shuttles. These companies were due to phase in from 1 October 1983 and relieve Rockwell International, Boeing, Martin Marietta, United Space Boosters and others over the following six months. Rockwell's loss of the processing contract came as a distinct shock to the Shuttle producer. Lockheed said that 85% of the current work force will be retained.

When Delta 172 hurled another RCA communications satellite into geosynchronous orbit on 8 September 1983 it reduced the number of remaining Delta launchers to seven. William Russell, deputy manager of the programme for the Goddard Space Flight Center, said McDonnell Douglas will end production this August. Two vehicles, 180 and 181, will be available as spares.

NASA's original Shuttle schedule anticipated elimination of Delta and Centaur by 1980 but those optimistic estimates were revised when *Columbia* arrived late. Russell noted that as he spoke the agency would release a request for proposals from industry to take over expendable vehicles like Delta, and the launch facilities, and operate on a profit-making basis. He said that some relatively new space firms had shown interest.

KSC CEREMONY

KSC Director Richard Smith presided at NASA's 25th anniversary observance on 29 September. Dr. Rudolph Stampfl of the National Institute of Electrical and Electronic Engineers presented a placque recognising the agency's efforts in those engineering fields. Sixteen NASA employees at KSC for the full quarter century were presented with certificates.

ON YOUR OWN

STS-9 was the last Shuttle mission for which NASA notified the press, TV and radio reporters concerning advance accreditation procedures. Henceforth the agency expects those wanting to attend launches to submit requests at least 15 days in advance by keeping informed of launch schedules.

THE MEDIA VIEW

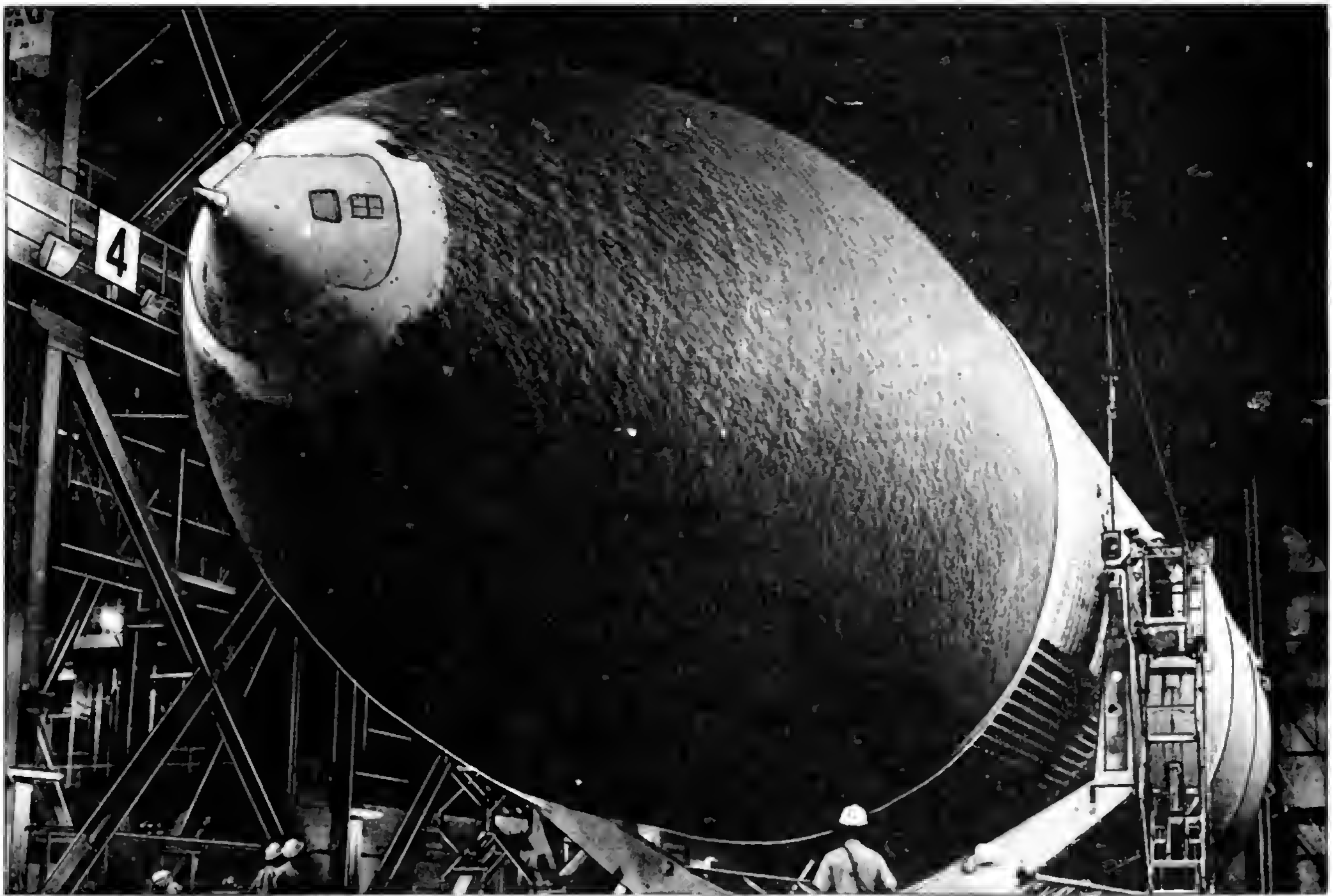
John N. Wilford, the *New York Times* space correspondent, who reported many events of NASA's "glory days" observed that STS-8 was "a freight run." The character of space flight is changing, he noted, "the familiar is less romantic."

As to NASA's future, while the agency observed its 25th anniversary on 1 October, Wilford remarked "there is increasing pressure to make space flight a paying, commercial proposition in which private industry plays a larger role, to work more closely with Defense... to spin off some civilian operations to other government branches, to maintain America's preeminence in the face of growing international competition from USSR, Europe and Japan and somehow establish a new vision of the nation's future in space."

Defence activities costing $8,500 M this year have surpassed NASA's $7000 M budget. The *NY Times* said the Reagan administration plans to increase military space spending by more than 10 per cent annually over the next five years.

Meanwhile, the *Times* commented, the Shuttle has become a matter of concern. "It remains to be seen whether the Shuttle can live up economically to advance billing," the newspaper added. "The four-Shuttle fleet was expected to fly 500 missions over a 12-year period... but officials long since abandoned predictions of two-

The space community was saddened by the death on 10 October 1983 of Kurt Debus, former Director of the Kennedy Space Center and one of the original V-2 pioneers. We hope to include a review of Dr. Debus' career in next month's "News from the Cape."



The massive External Tank for the STS-9/Spacelab 1 mission is seen here after the Shuttle stack was disassembled to allow engineers to replace a suspect Solid Rocket Booster nozzle. Note the texture of the insulation covering. NASA

week turnarounds. The present goal is 24 launches a year by 1988, 30 by 1990 and 40 by 1992."

The National Research Council recently concluded that the chances of 30 a year by 1990 were "impossible or highly improbable." Unless Shuttles can generate annual revenues of $2000 M or more, as Administrator James Beggs forecast, NASA will be unable to support a more aggressive programme.

LOUSMA RETIRES

Astronaut Jack Lousma, aged 47, who commanded STS-3, has resigned his positions with the space agency and the US Marine Corps. He was also a member of the second Skylab crew in 1973.

Beginning an annual selection of Shuttle astronauts, NASA accepted applications for six pilot and six mission specialists positions until the closing date of 1 December 1983. The miliary services also screened candidates because at least one Defense member will fly with every military payload.

HERE IS THE FORECAST...

One can usually find some humour in otherwise serious situations. As when Major Donald Green, US Air Force meteorologist, confidently assured NASA launch chiefs and press that favourable weather was at hand for the launch of STS-8. He delivered this forecast at the final pre-launch press conference on the morning of 29 August in front of Lieutenant General James Abrahamson; Al O'Hara, KSC director of Shuttle launch and landing; Glen Lunney, chief of the Johnson Space Center Shuttle management team; TV commentators and newsmen. While Green said that showers could be expected during the afternoon and evening, he was very sure all rainfall would cease and a quarter Moon would shine on the launch pad during the early hours when the launch was due.

Major Green was "slightly" wrong. Thunder, lightning and rain fell upon more than 1,000 press, 6,000 invited guests, and 40,000 other spectators around midnight and continuing into early morning. One observer remarked, "The Major may be a Captain tomorrow if this continues." O'Hara held the count at T minus 9 minutes until rain ceased and *Challenger* took off through a heavy cloud bank.

As an additional safeguard, astronaut Bob Crippen flew around the launch area to make sure there was no lightning within 8 km of the pad. His 'OK' was the clincher for O'Hara. But the press was looking forward to STS-9 (Spacelab) and Major Green's pre-launch forecast.

A reporter's query about STS-9 during the STS-8 pre-launch conference touched sensitive nerves. It was pointed out the launch azimuth for Spacelab, 57 degrees, would carry *Columbia* and its payload across portions of the USSR. Since the crew were to dump the External Tank (this occurs over Indian Cocean on other missions) there may be some hazard to the impact area. Had NASA talked about this with the Soviets?, it was asked.

General Abrahamson deferred to Glen Lunney of the Johnson Space Center. Lunney pointed out that NASA informs the appropriate United Nations directorate in advance of all launches and also publishes warnings to aviation and maritime interests. Another query: had NASA told the US State Department? No direct reply. Instead the KSC moderator, Hugh Harris, pointed out the meeting dealt with STS-8 and questions related to STS-9 were not appropriate.

COLLECTING COSMIC DUST

Dr. George J. Corso*

The advent of the Space Shuttle has spawned many new space science proposals. Not least is the novel idea outlined below which suggests that a satellite attached to the Shuttle by a long wire would be ideal for collecting very fine grains of cosmic dust for analysis. The author considered the proposal in more detail in the September 1983 issue of the Journal.

Introduction

Most cosmic dust particles larger than a few microns (1 micron = 10^{-8} cm) are believed to be cometary debris released as comets are heated by the Sun [1–4]. Some might have different origins, perhaps from collisions between asteroids, or as ejecta from impacts on the Moon, or on satellites of the other planets. Some must come from the interstellar medium as the Solar System passes though on its galactic orbit around the Milky Way.

The chemical nature and relation of the smallest (micron and below) of these particles found between the planets to the larger zodiacal dust particles is of considerable interest to Solar System astrophysicists. Chemical analysis would tell us if they are simply collision fragments from the zodiacal dust or, as some investigators have recently proposed, a separate population [5–7]. Even if we find them to be merely collisional fragments, analysis may reveal significant changes during their history.

The Problems of Collection

Until now the collection of most cosmic dust has been in the stratosphere using aircraft and balloons. However, there are many problems with collecting and identifying the smallest particles (less than 2 or 3 microns) in this region. The most severe is contamination by opaque aluminium oxide rocket exhaust particles, and others such as volcanic emissions, carbon soot from supersonic aircraft, windblown rock, soil, sand, ash from forest fires, spores and even insect parts. The eruption of El Chichon in Mexico threw so much sulphate material into the stratosphere that NASA was forced to stop all dust collections for a year.

Particles from all of these different sources mix together as the cosmic portion slowly falls into the stratosphere from the upper atmosphere (where it is decelerated from its cosmic velocity). The 1–2 micron particles reach the stratosphere in several weeks or months after striking the atmosphere, depending on their densities and the effects of mesospheric winds and circulation. Once in the stratosphere they can remain there anywhere from several months to a year, during which contamination of their surfaces from terrestrial aerosols is likely to occur.

This gradual downward drifting also makes it virtually impossible to separate out any "fresh" dust released from a comet from the background of the "old" zodiacal dust particles residing in the stratosphere. Otherwise, we might be able to spot chemical variations in the debris of different comets.

The only way to improve this time resolution and minimise contamination is to collect dust from *above* the stratosphere. Although some valuable information came from studying micrometeoric craters in materials carried aboard Skylab and the Space Shuttle (and even more will come from the Shuttle's Long Duration Exposure Facility) the probability of anything more than a tiny amount of "useful" (for example, chemically fractionated) micrometeoric debris being returned from space with this approach is very low. At the high velocities of most of the cosmic dust at orbital altitudes (greater than 11 km/sec) most of the particles vaporise on impact. Furthermore, even though terrestrial contamination may be avoided by Earth orbiting satellites, contamination by orbiting rocket exhaust particles and spacecraft debris cannot.

* *Dr. Corso is with the Dept. of Physics and Astronomy, Indiana University Northwest, USA.*

Deploying a tethered satellite from the Space Shuttle. Note that the support structure is based on ESA's Spacelab pallet.

The Tethered Satellite

The ideal collection method for the smallest particles would be to use an upper atmosphere satellite attached to the Shuttle by a very long cable. Such a satellite is being developed by NASA's Marshall Space Flight Center [8]. The tether might be as much as 100 km long so that the satellite would be low enough in the upper atmosphere to take advantage of the gradual deceleration imposed on the smallest micrometeoric material by collisions with upper air molecules (but still be above terrestrial contamination and far below Shuttle debris and orbiting exhaust particles). The number of particles is also much greater at a height of 120 km than at the Shuttle's altitude because of the stacking effect that occurs due to the decelerating influence of the atmosphere.

A cosmic dust satellite would carry clusters of individual small collecting surfaces protected by iris covers and arranged around the outer surface. The covers would protect the collecting surfaces from Shuttle debris during the deployment and retrieval stages. So as to minimise

2. The exhaust from the solid rocket boosters is rich in hydrochloric acid — very corrosive to the electronics, circuit boards and all exposed metal surfaces.

In order to line up the cameras without dismantling the containers, a window is mounted in each unit to allow me to see the cameras' ground glass screens.

To activate the cameras I rely on a sound trigger. I chose this method because I felt that I would, if the switch was tuned sensitively enough, capture the early moments of the launch more effectively. As it turns out, the switch is sensitive enough to be activated by the sound created by the igniters lighting the Orbiter's three main engines. This comes several seconds before the engines reach full thrust and seven to eight seconds before the solid rocket boosters ignite.

The sound switch has within its own case a battery and silicon rectifiers to trip a reed switch (a form of relay) to fire the cameras. The rectifiers are stimulated by a microphone that protrudes out of the front of the protective boxes, pointing towards the Shuttle. A digital clock with an alarm is included in the switch. The trigger's sensitivity would make it vulnerable to premature firing by other noises before launch so the switch is made active by setting the alarm on for 60 seconds before Shuttle ignition. Helicopters check for intruders several minutes before launch and the sounds could activate the cameras prematurely.

About 24 hours before launch I take my cameras to the remote sites. Before then, however, much careful prepatory work has to be completed if the two four-camera units are going to work effectively:

1. Check all cameras, backs, lenses and sound switch for perfect function.

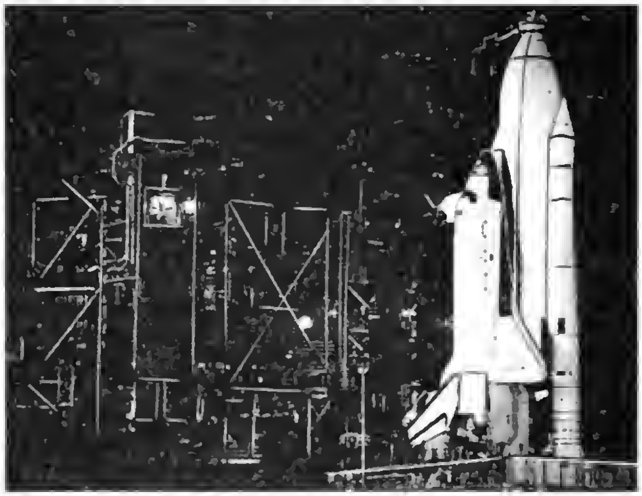
2. Charge all batteries in the cameras and sound switch to their full capacity.

3. Select the lens and film magazine combination. Over the last few launches I have been using 2–250 mm and 2–150 mm lenses; one of each in each protective box.

4. Select the film. My objective is to report the Shuttle for newscoverage but a much more significant reason is to record the launches for posterity and to offer a different perspective from NASA's own photographs. Because of this, I make sure I use fine grain black and white film as well as colour in each camera unit. Colour film probably won't last longer than 50 years but black and white, with careful processing, will last indefinitely.

5. Select exposures and F stops for the cameras. As the cameras are set up 24 hours before launch and no access to them is possible after they have been left, careful 'guestimates' of exposures have to be made of what the light level will be on the day of the launch. I always set the cameras for 500th of a second to eliminate problems created by vibration. The vehicle also moves rapidly off the pad after release of the eight bolts around the bases of the solid rocket motors; the 500th speed helps to stop the smear of the image that would occur with a slower speed.

Facing page: the first launch of "Challenger" (STS-6, April 1983) is captured by the author's camera at Remote Site 1.



STS-1 on the pad, ready for launch, April 1981. M. M. Taylor

6. Filter preparation: the evening and morning humidity levels can be severe at the Cape. This humidity has a tendency to put condensations on all exposed lens and filter surfaces when left outside all night. Some photographers use time release doors that cover their lenses. I use an anti-fog liquid (similar to that used by the astronauts on the inside of their helmets to keep condensation off their face plates).

7. Closing the camera boxes: the four camera bodies and appropriate lenses are carefully mated, focussed at infinity and the predicted exposure set. The camera and lenses are now firmly bolted to the two base plates. The sound trigger is attached to the camera platform and the clock is checked for accuracy with a National time signal. At this point the microphone is placed in its directional tube and several tests of the system are made before the loaded film magazines are put in place and the film protection slides withdrawn. The appropriate switches for the continuous running of the cameras are now set before the remaining top portion of the box is placed over the camera mount platform and the two segments bolted together. The completed untis are now ready for the remote camera sites.

NASA delivers us and our vast quantities of equipment to the remote sites usually on three buses, one for each site, and provides a small shuttle bus to transport us from one site to another. The camera positions are chosen 2 days before launch, and our places marked. NASA gives us about 5 hours to do the work but I am usually back at the Press site 90 minutes later. One vital item is to attach one's sturdy tripod to the ground. Doing this saved my cameras in the storm mentioned earlier on STS-4. The remote sites looked like a scrap yard for cameras after the storm — quite a number of photographers came back after the deluge and high winds to find their clusters of cameras floating or submerged in the lagoons.

I also tape aluminium foil over each box to reflect the hot Florida sunlight to keep the insides reasonably cool.

There are a number of items beyond my control. The major one is that the Shuttle may not take off at all if anything has gone wrong during the countdown. The weather also has to be favourable, with no more than 50% cloud cover and winds no stronger than 18 km/hr.

The launch of a Space Shuttle is one of the most moving and impressive experiences that I know. Anyone who has seen a launch, experienced in space research of not, never looks again at the space programme in quite the same way.

ESA's TELECOMMUNICATIONS PROGRAMME

BY Simon E. Dinwiddy*

Communications satellites are now firmly established as a vital part of the world's telecommunications networks. The role they play will continue to expand. Simon Dinwiddy of ESA presents an overview of the past, present and future of these satellite in a European context.

Introduction

This review covers the European Space Agency's telecommunications satellite programme. This programme is half of the Applications Programme, the other half of which comprises meteorology and Earth resources.

The predecessor to ESA, the European Space Research Organisation, was founded in 1964 to foster space research in Europe, mainly by building and operating scientific satellites carrying European experiments. Some of the early satellites carried several experiments, each provided by a different research institution. Later satellites have been more specialised but the introduction of STS, better known as Shuttle, has led to the development of re-usable manned and unmanned space research vehicles, Spacelab and Eureca.

In 1971, the scope of ESRO was extended with the start of the Applications Programme. This consisted initially of Aerosat, Meteosat, Marots and ECS, with its forerunner OTS.

The Programmes

Aerosat was to be a system of geostationary satellites providing communications between aircraft and air traffic control centres, giving coverage of the Atlantic and Pacific regions. The project was eventually shelved because, on the one hand, the expected increase in pasenger traffic was taken up by the introduction of larger aircraft (rather than more aircraft) and, on the other hand, the supersonic aircraft, which it was anticipated would cause complications because of their different flight patterns, never became a commercial success.

The first satellite in the Meteosat weather satellite programme worked perfectly for two years, until the failure of a single resistor resulted in the whole camera system being put out of action. Meteosat 2 was successfully launched by Ariane in June 1981 and its pictures are a regular feature of many TV weather reports throughout Europe.

The maritime satellite programme has also been a success. The original experimental programme, which was to have led to the launch of a single Marots satellite, was upgraded to an operational programme with two Marecs satellites to be launched.

The first, Marecs-A, was launched by Ariane L04 in December 1981 and has now been operating over the Atlantic Ocean as a part of the Inmarsat global network for over a year. The Inmarsat network has expanded beyond all predictions and now serves over 1000 ships. The ship terminals give access, *via* shore stations in all three ocean regions, to the telephone and/or telegraph networks from any point round the world.

Marecs-B was unfortunately dropped from a great height when the Ariane L5 third stage failed nine minutes after lift-off. The spare hardware was produced to form a replacement Marecs-B2, which will be launched, possibly in March 1984.

Marecs 1 under construction. Launch came in December 1981.

The first satellite in the ESA fixed-satellite-service programme, OTS 1, was dropped by a Delta rocket, but not from such a great height, so we actually recovered a considerable quantity of equipment from the sea-bed. Some of it, though already barnacle-encrusted, was still working to specification. OTS 2 was put together by refurbishing the test prototype and was launched in May 1978.

OTS 2 has completed five successful years in orbit. During the early part of this period operations concentrated on the Orbital Test Programme, which featured mainly digital transmission and high-speed TDMA* tests and propagation measurements to prove the basic concepts of the ECS trunk telephony service. Later, the programme has expanded into new applications. For over two years, OTS has been used daily to relay French TV broadcasts to Tunisia and last year Satellite Television Ltd started transmitting Europe's first commercial satellite television programme from England to Finland, Switzerland and Malta. In another field, that of data communications, the Stella and Spine experiments have proved the feasibility of using small Earth stations, located within the user's premises, to provide very high speed data links. OTS 2 is now nearing the end of its life, as the station-keeping fuel is becoming depleted. The possibility of

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* *Time Domain Multiple Access; a method of transmitting information.*

prolonging its active life by allowing the orbit inclination to degrade without making North/South station-keeping corrections is being discussed. The last reserves of fuel are to be used to remove the satellite to a higher orbit, at a safe distance from the geostationary circle, to avoid the risk of collision with operating satellites.

The new applications of OTS have led to a broadening of the scope of the ECS system. Originally, ECS was to provide trunk telephone and TV distribution services between large Earth stations. These stations will interface with international switching centres, the point in the telephone network most remote from the subscriber. They are often also located far from the city centre to avoid interference, and are thus also physically remote from the subscriber.

The success of OTS TV distribution experiments and of similar operations in the United States has led to the re-deployment of the first ECS satellite to serve the TV market. Eutelsat and ESA are discussing the launch of a third ECS in addition to the two already planned; a launch slot has already been reserved with Arianespace in 1985. In conjunction with the development of cable networks, ECS will be able to offer international television to suit every member of the largest family.

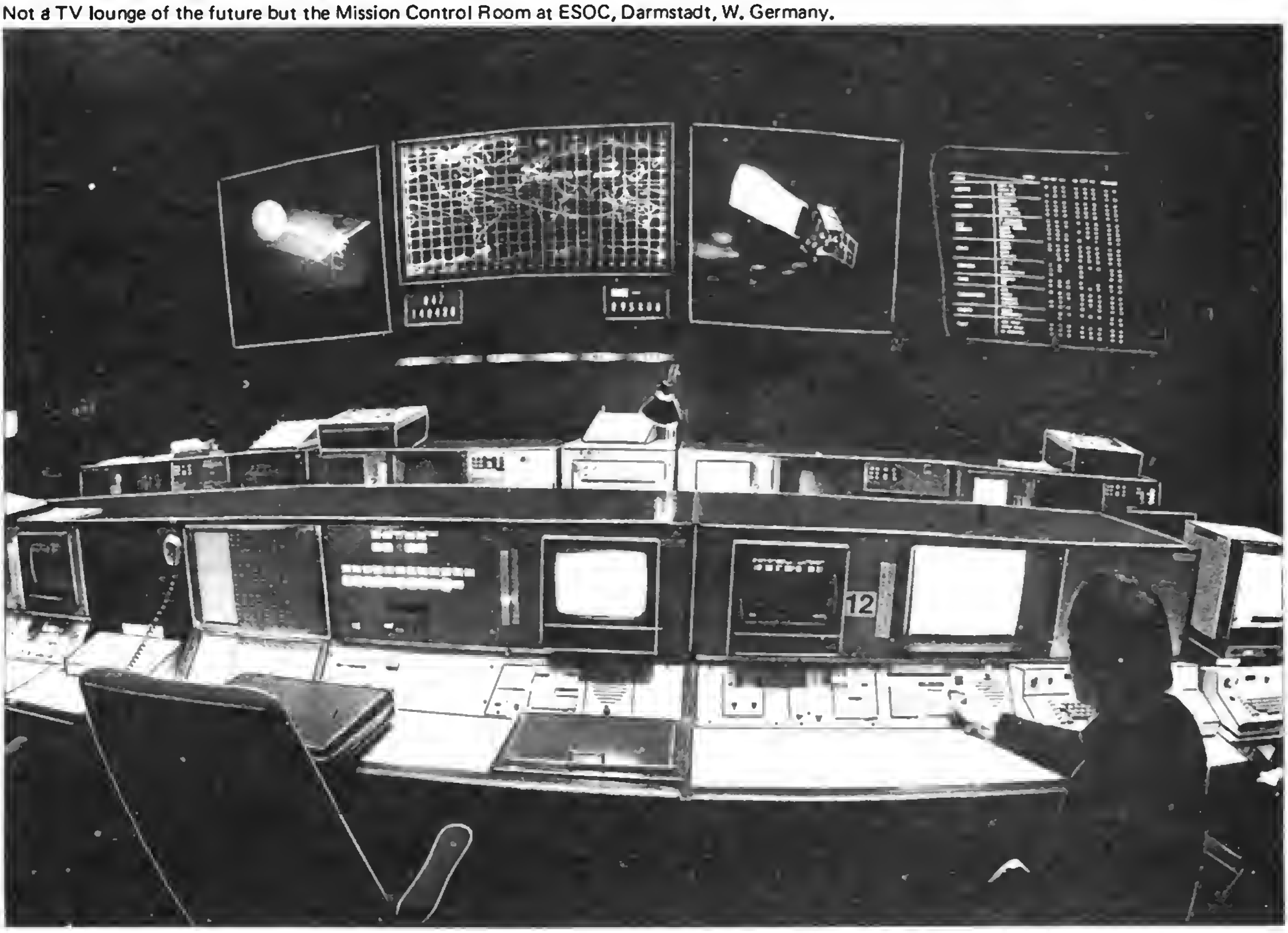
The recognition of a demand for services such as bulk data transfer, newspaper page facsimile and video teleconference has led, after much discussion, to the addition of a "Specialised Services", or "Satellite Multi-Services" (SMS) module to the later four of the five ECS satellites. These services require high-speed digital links which cannot be provided by existing communications networks (mail, telegraph/telex, telephone or the new data networks) and which are even likely to fall outside the scope of the new Integrated Services Digital Network (ISDN), which is planned to unify the telephone, telex and data networks. A satellite system can provide such services direct to small Earth stations located either on the users' premises, in the parking lot or on the roof-top, or close to the users' premises, down-town. An essential requirement in Europe is the use of the rare bands in the frequency spectrum which are free from interference from the dense microwave radio relay network. The ECS-SMS system will use parts of the 14.0-14.3 GHz uplink and 12.5-12.75 GHz downlink exclusive frequency bands. The penalty of using small Earth stations is a reduction in the traffic capacity of the satellite repeater. The ECS primary service telephony repeaters carry 120 Mbit/s signals which, with digital speech interpolation, can handle up to 1800 two-way telephone circuits, but the ECS-SMS repeaters will be able to handle only a few hundred 64 kbit/s channels. However, the possibility of a direct connection to the Earth station and of a versatile and flexible digital link through the satellite add more than enough value to compensate for this extra cost. The forthcoming launches of ECS are thus not merely of interest but critical to the future of ESA, Eutelsat, European PTTs telecommunications agencies, television companies and communications users.

Olympus/L-Sat

The basic *modus operandi* of the Agency's Applications Programme is the development of European industry, by means of research and development contracts, to make Europe capable of competing successfully in the world market for applications satellites.

The need to provide a practical demonstration of the capability of European industry, which led to the satellite projects of the Applications Programme, required ESA to take a direct role in the "Commercial cycle", by placing contracts directly with industry and making agreements

Not a TV lounge of the future but the Mission Control Room at ESOC, Darmstadt, W. Germany.



with the appropriate operator organisation. Indeed, in the case of both Marecs and ECS the corresponding operator organisations, Inmarsat and Eutelsat, were created after the satellite projects had been initiated.

ESA maintains contact with users, operators and others in the "commercial cycle" by means of formal as well as informal discussions and has given direct assistance to PTTs, broadcasting agencies and other users and prospective users of communications satellites by means of consultancy contracts.

As a result of these contacts and of extensive in-house studies, the Agency identified a large potential market for large satellites, of up to 3500 kg mass at lift-off, with up to 500 kg payload mass and up to 7 kW array power, for launch by STS, Ariane 3 or Ariane 4. To prepare for this market, ESA have commissioned the development of the Large Telecommunications Satellite and the launch, planned for 1986, of the prototype, fitted with four Service Demonstration Payloads. The name of the project has been changed from "L-Sat" to "Olympus", under which name the class of satellites is to be marketed. The selection of the four payloads and their design involved not only the Agency, the delegations of member states participating in the programme and the satellite contractors but also the communications industry, operators and experimental community.

The four payloads of L-Sat are:

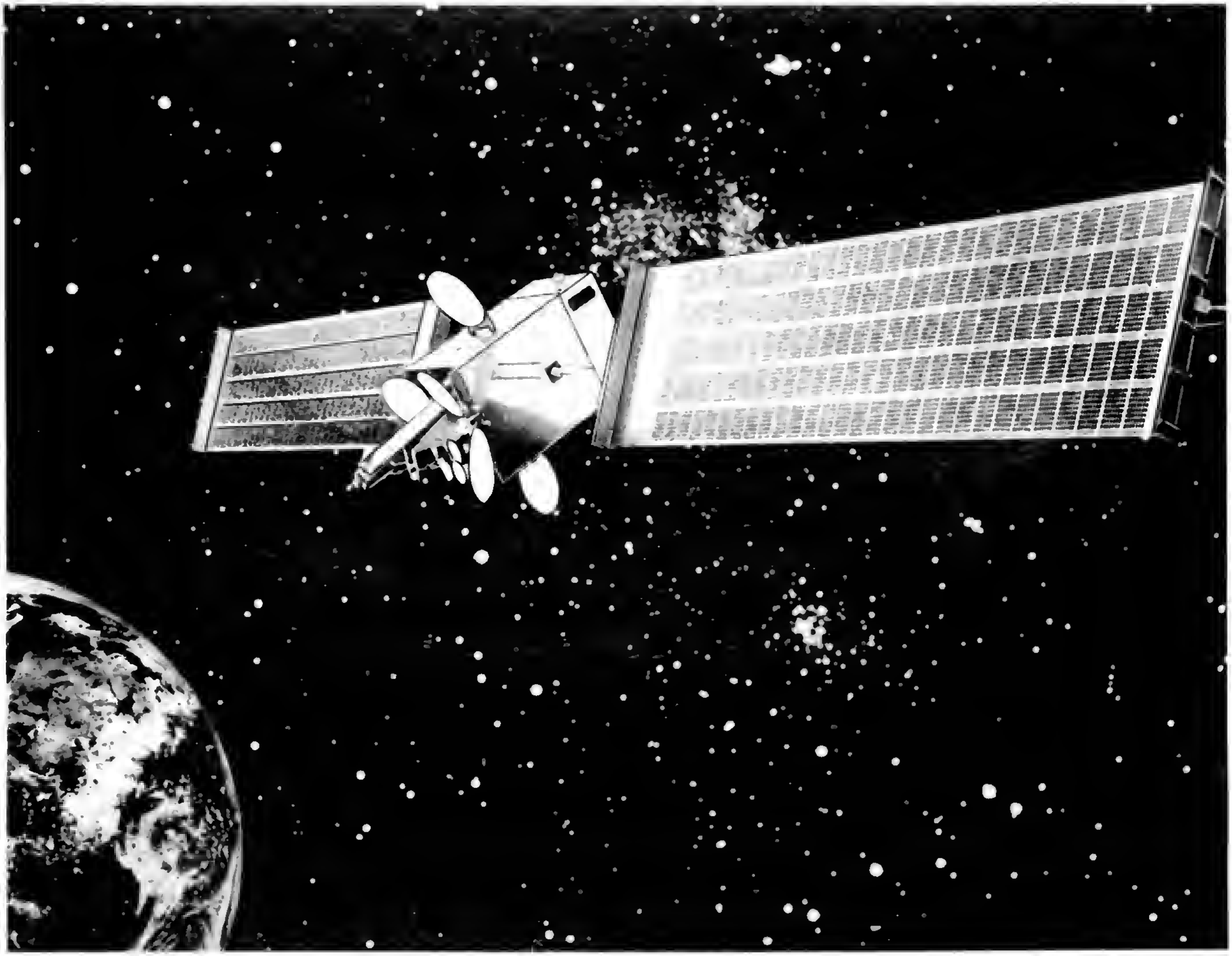
- the Propagation Payload
- the Specialised Services Payload
- the Television Broadcast Payload
- the 20/30 GHz Communications Payload

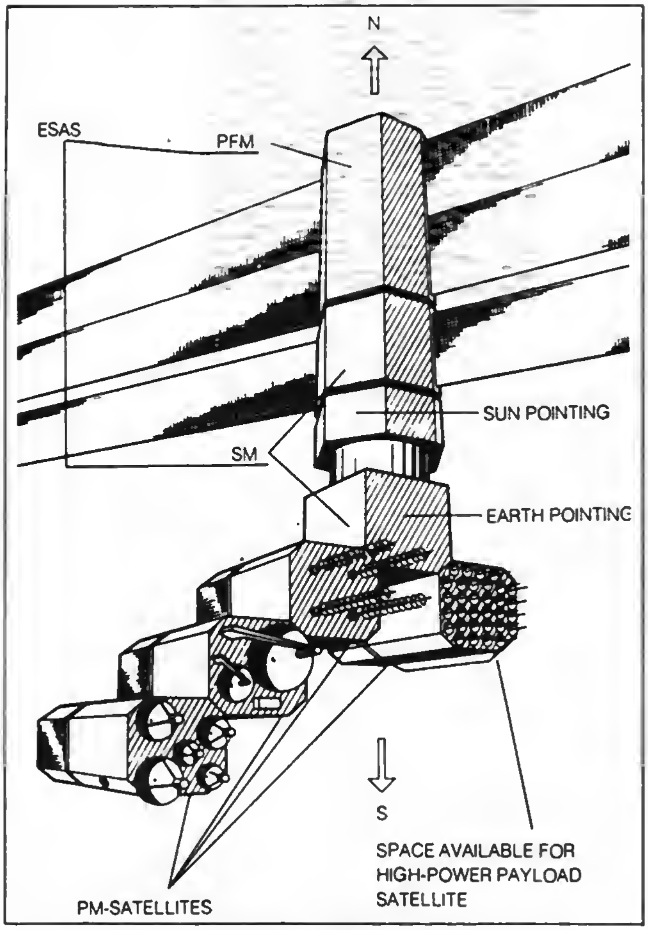
The propagation Payload provides carrier-wave beacon transmissions at 12.5, 20 and 30 GHz which may be used for attenuation and cross-polarisation measurements (important effects in radio communications) and also as a tracking reference. The nominal coverage of the 12.5 GHz beacon is global and of the 20 GHz and 30 GHz is European, though the latter may be received, with possibly degraded power and power stability, over the visible globe.

The Specialised Services Payload provides advanced features of a possible future specialised services satellite. It incorporates a five-beam antenna and a four-channel repeater with a matrix switch for routing burst signals by SSTDMA (Satellite Switched Time-Domain Multiple Access). Bandwidth reduction by frequency re-use and multi-point signal routing are additional features of this highly adaptable payload.

The Television Broadcast Payload is the principal payload of L-SAT, providing two high-power repeater channels, each with redundant 200 watt transmitters. One channel has an elliptical transmit antenna beam with radio-frequency tracking to give coverage of Italy with full compliance with the exacting requirements of the WARC-1977 (World Administrative Radio Conference). The second channel has a steerable beam, which allows experimental service to individual receivers, with 90 cm antennae, in any European country. Alternatively, by suitably orienting both beams, a European coverage may

An artist's impression of L-Sat (Olympus) in orbit.





Possible configuration of European Space Assembly System (ESAS). The SM (Service Module) and PM (Payload Module) satellites are launched independently and joined together in geostationary Earth orbit (GEO). Additional PMs and PFMs (Power Function Modules) are added from time to time as required).

Large and remote: The OTS ground station at Fucino, Italy.

be obtained, serving community receivers with 3 antennae.

The 20/30 GHz Communications Payload provides a basic, flexible vehicle to allow exploratory tests and demonstrations in the challenging new millimetre-wave frequency bands. Two transparent repeater channels are provided with two independently steerable spot beam antennae able to provide communications at 8 Mbit/s between Earth stations with 3 or smaller antennae located anywhere on the visible Earth (as seen from the satellite).

The Agency has issued invitations for proposals for experiments and demonstrations using L-Sat and has received a wide range of interesting suggestions.

Video teleconference for business and educational purposes features high on the list of applications of both the Specialised Services and the 20/30 GHz Communications Payload. Of particular interest is multi-point video teleconference which would take advantage of the inherent broadcast nature of the satellite to allow a round-table meeting to take place between three or more locations with full visibility of each of the locations at all of the others. There is a fundamental question here of how many TV screens a viewer can concetrate on simultaneously.

Use of the 20/30 GHz communications payload for wide-band communications experiments at data rates up to 800 Mbit/s is also being discussed. These experiments, which may be based on the SERC 25 m Earth station at Chilbolton, would investigate the influence of the atmosphere and pheonomena such as high altitude atmospheric turbulence and rain scattering on the very short term phase stability of the transmission path.

A new and quite different application for L-Sat is its use as an inter-orbit communications link between the European Retrievable Carrier (Eureca) and one or more ground stations in Europe. Eureca is a re-usable platform for scientific experiments, which will be launched in 1987 from Shuttle into low-Earth orbit at an altitude of 500 km for a period of six months, after which it will be brought back by Shuttle for refurbishment prior to a second mission planned for 1989. During this second mission, it is hoped to launch a second space vehicle for unmanned rendezvous and docking experiments, for which the link *via* L-Sat could be an essential requirement.

The inter-orbit communications link would provide valuable experience to support studies of satellite clusters. ESA are examining a range of satellite cluster concepts which would allow independent satellites to cooperate by communicating directly with each other over inter-satellite links (ISLs). Clusters could simplify the Earth station requirements for a hierarchy of domestic, regional and international satellites and could possibly improve the traffic capacity of the geostationary orbit.

The unmanned rendezvous and docking experiment would be the first practical step towards another major concept of the future, the assembly of satellites in geostationary orbit. Such assembly could serve to build larger, more efficient satellites in orbit, to refuel, repair and maintain satellites and to add new modules to satellites both to provide growth capability and to introduce new and more efficient technology.

It is perhaps appropriate that ESA, having encouraged international cooperation in industry to the highest degree, should propose concepts which call for the highest degree of cooperation in space itself.

SATELLITES AND SOFT ERRORS

By Dr. David G. Stephenson

The wit who first coined the comment about draining a swamp and then becoming aware that the glutus maximus was threatened by the local alligators probably had the modern communications satellite operator in mind. Even after the alarms and excursions of the launch and insertion phases are over and the new communications link is safely in geostationary orbit, his troubles are by no means over. That orbit is unstable and the satellite must remain on station with a minimum. of fuel loss. The satellite must remain under thermal control even though power consumption and solar illumination changes. The solar cells and transponder electronics degrade with time and eventually fail, and not least the low energy electrons that create the aurora on Earth also cross the orbit and can make a spacecraft spark over. So satellite designers can be forgiven for getting a little short tempered with scientists who predict that what is now a minor irritation may become one of the factors limiting the performance of future generations of sophisticated communications, and other data handling, satellites, even to. the extent of a whole new philosophy for the handling of thousands of millions of dollars worth of information each year. But there is concern [1] that high energy atomic particles, which are too sparse to cause bulk effects such as spacecraft charging, may pose a threat to the use of modern digital large scale integrated circuits in future spacecraft, and discussions have begun to develop a mission to collect the basic data needed to evaluate this problem.

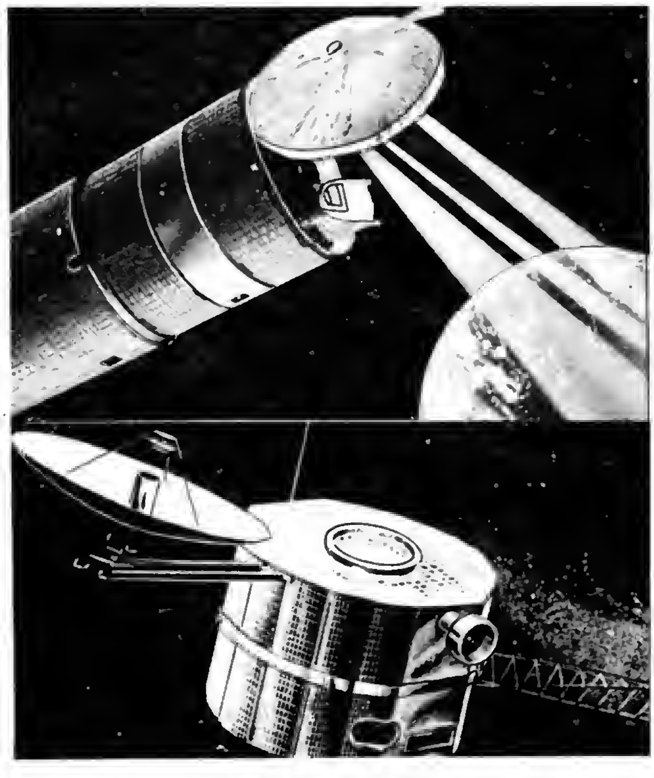
Introduction

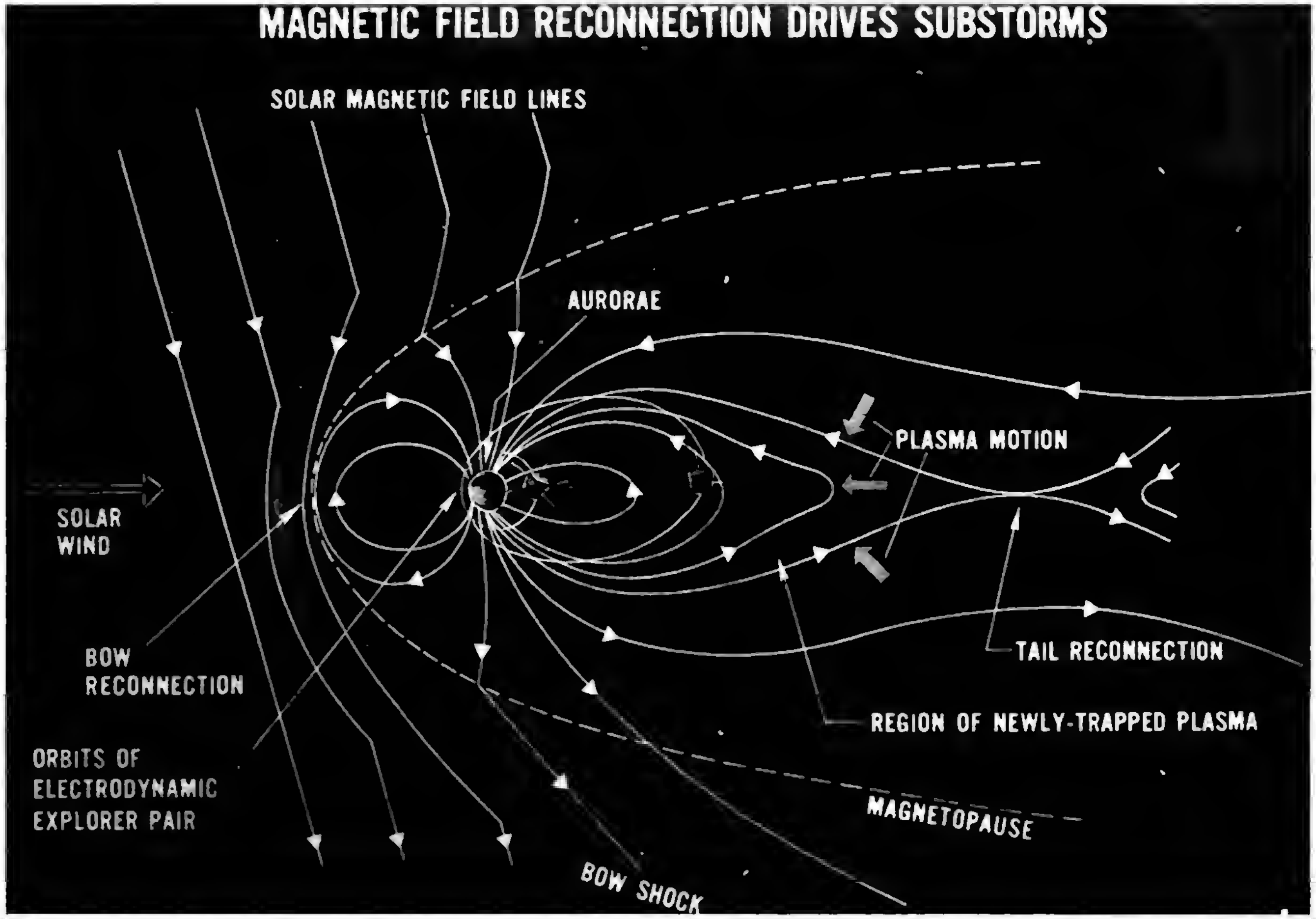
The chance combination of the Earth's rotation rate and the strength of its magnetic field has meant that, as far as high energy particle bombardment is concerned, the geostationary orbit (35,900 km up), if not the worst place to park a satellite, is certainly one of the worst in the neighbourhood of the Earth. The Sun's outer atmosphere is continually streaming past the Earth as the solar wind, and where this electrically conducting stream of hydrogen gas or, technically speaking, plasma of electrons and protons collides with the Earth's magnetic field, it distorts into a comet-like shape, with a compressed zone towards the Sun, and a magnetic tail streaming off into interplanetary space on the night side. Many of the details of the processes that cause and sustain this shape are still poorly understood, even after over 20 years of dedicated research work since the original discovery of the Van Allen radiation belts of trapped particles in the Earth's magnetic field. Our ignorance is most marked at the boundary region between the solar wind and the Earth's field. Here a shock front exists with particles from the solar wind sometimes being accelerated to energies equivalent to 10s of millions of electron volts, sometimes crossing the boundary to become trapped in the Van Allan radiation belts, and sometimes even finding their way to a stagnant sea of low energy particles deep in the magnetic tail beyond the orbit of the Moon.

Most scientific effort to date has been concentrated on the lower energy particles and electrons found near the geostationary orbit, as they are the cause of currently commercially significant effects such as magnetic storms on Earth and spacecraft charging in space, and they are sufficiently numerous that accurate statistics of their spatial and temporal distribution are easy to obtain. In addition, the studies of the complex dynamics of these natural plasmas are a unique source of information on the behaviour of magnetically confined large scale plasmas, and so have made important contributions to the programmes to harness the fusion of light elements to generate electrical power. Very few scientific satellites have measured the high energy particles found in the geostationary orbit, with any useful spectral resolution of energies above 1 MeV, even though the working rule of thumb is that particles with energies above about 25 MeV can penetrate modern spacecraft.

The limited information that is available indicates that at times of solar disturbance large fluxes of energetic protons occur in geostationary orbit, for the solar wind is not constant, and as it varies so does the position of daytime shock front of the Earth's magnetic field acts rather like a softly inflated balloon. Under quiet solar conditions, the solar wind is weak and steady, and the shock front is stable and situated about 10 times the length of the Earth's radius away from the Earth towards the Sun. After a solar flare the interplanetary plasma flow increases and the shock is pushed back to within 5 radii of the Earth, and becomes spacially unstable. The geostationary orbit has a radius of 6.6 times that of the Earth, so when a communications satellite is on the day side of the Earth it can, magnetically speaking, be in interplanetary space, or well inside the Earth's magnetosphere (as it always is during the night), or worst of all in the complex boundary regions between the two. Even during quiet periods a communications satellite must orbit along the fringe of the outer Van Allan belt with its population of high energy protons.

In addition to the solar protons, cosmic rays of high atomic mass and energy arrive near the Earth from interstellar space in a more or less constant stream. This is modulated by interplanetary plasma streams during short periods of intense solar activity. The most penetrating particles can plunge deep into the Earth's atmosphere to create showers of secondary particles at the





surface, or can affect the retinas of astronauts in low Earth orbit, giving the impression of points of light against closed eyelids. Less penetrating cosmic rays can be deflected away from the Earth by its magnetic field, but even during periods of low solar activity this protection is only partial at the geostationary orbit.

The Problems of Satellite Design

The reason why high energy particles could become a serious concern for satellite designers and operators of the next decade lies in the growing demand for digital communications *via* satellites and the structure of the sophisticated modern micro-electronics needed if this demand is to be satisfied economically and within the limited slot allocations of the geostationary orbit.

A modern integrated circuit consists of a layer of semiconductor material that has been modified to contain many thousands of sandwiches of selected semiconductor material between two or more layers of other conductors or semiconductors. Depending on the materials in the sandwich it can act as a transistor, a resistor or a charge storing capacitor. In digital integrated circuits of the type found in modern computers the electrical charge stored in the middle of a circuit element, or more correctly the field across the junction between layers in the sandwich, determines if the whole circuit is in a 'one' state, or a 'zero' state. During the 1970's computer designers on Earth were surprised to find that errors were occuring in the latest range of experimental systems. Eventually the errors were traced to atomic radiation, partly from radioactivity in the ceramics used to encapsulate the integrated circuits, and partly from the secondary cosmic ray background coming from space. When an interstellar cosmic ray passes through an integrated circut, the field around the particle is enough to drag electrons from the semiconductor material. This makes a cylinder of positive and negative charges that can reverse the state of the circuit element and generate an error in the related data stream if the particle passes close to a sensitive junction area. If the particle is heavy or energetic enough it may destroy the circuit element entirely. A proton, such as those found in the geostationary orbit, is too light to generate a charged region of its own; instead it interacts with the nucleus of an atom in the semiconductor, creating a shower of a secondary particles, which form a micro-plasma that may affect a sensitive junction and so cause an error.

Actual destruction of circuit elements by radiation has been the focus of attention for many years, and a limited range of radiation hardened components that can survive exposure in space are available. The best demonstration of what can be achieved in this direction was the Voyager flights through the intense radiation belts of Jupiter. But during those flights the on-board computers were not fully operational, and even so errors appeared in the programmes stored in the spacecrafts' memories. Back on Earth such 'soft' or reversible errors are minimised by carefully chosen encapsulating materials for integrated circuits and, since mass and power are cheap, part of a computer's gross performance can be dedicated to cross checking the reliability of the data in the memory stores. But in space mass and power are expensive and the radiation environment is much more severe, so reversible errors are now becoming a concern of researchers developing the technology to be used in future space communications systems.

As integrated circuits become faster and more sophisticated their elements must become smaller, and so the electrical charges used in them become smaller and easier to neutralize. Even though they are sophisticated spacecraft, modern communications satellites are fundamentally simple devices, using electronic systems several steps behind the current state-of-the-art on Earth. Besides a command transceiver and controlling computer, a satel-

lite has several transponders, each of which is a receiver for the up-link from Earth, a frequency translator, and a transmitter to send the signals back to Earth. Little or no processing of the communications traffic actually takes place on the satellite, other than switching circuits for the antenna feeds. The circuits are simple enough so that components with large and insensitive junction areas, immune to all but the effects of the most energetic cosmic rays, can be used. Even so occasional anomalies have been reported in the control computers of communications satellites. Cosmic rays are a useful and ligitimate scapegoat, to carry the guilt for these embarrasing events. However, the demand for communications satellites is increasing rapidly, and a large proportion of the increase will be due to growing computer networks that handle high speed digital data streams. If these, and widespread conventional networks that also use digital techniques, are to be handled efficiently, future communications satellites must become an active and sophisiticated part of the data handling system. The forerunner of these satellites will be Intelsat 6 with its complex route switching systems.

Typical of modern methods for transmitting digital data are the many forms of packet transmission. This allows a collection of computers all to transmit on a common channel using a standard format in which a fixed quantity of data containing a self-checking code make up a packet. A routing code in the packet commands the intended receiver to check the accuracy of the incoming information, and to demand the packet be repeated if errors are detected. If such a system were to be used from a satellite to a network of Earth stations, the unavoidable delay in sending a signal from the satellite to Earth would mean that a large quantity of data would have to be stored on board the spacecraft, where it could be degraded by high energy particles. Not only that, but the control of these services would demand the equivalent of a substantial modern computer to be in the spacecraft, and the programmes and working data of this controller would also be vunerable to radiation effects.

The most popular design of current communications satellite is a spin stablized cylinder. With its surrounding solar cells and structure it provides a degree of protection from penetrating radiation. In future, satellites will deploy antennae and solar arrays away from the satellite body with its electronics, losing the present protection. Furthermore, the increasing use of low atomic mass materials such as beryllium or carbon composites will result in the scattering of cosmic particles in the satellite, rather than their absorbtion - the electronic components may become even more exposed.

The Future

Just how important the effects of particle-induced soft errors may be is currently very much a moot point. We could hope that the effects will be minimal and limited to occasional control and data transfer malfunctions (which, however, could be disastrous in a military satellite). It must be remembered that commercial data links require a reliability of 99.97%, so even a very low error rate could become very expensive. Until a thorough investigation has been completed, and working rules for the design of future satellites have been made available, using modern integrated circuits in the geostationary orbit will be a risky proposition. The importance of this problem can be gauged from the fact that the American space authorities, at a time when research programmes are being eliminated in order to reduce expenditure, are seriously considering a mission to clarify the situation, and to attempt to compare the effects of high energy particles on various types of integrated circuit. The mission is to be called the Chemical Release and Radiation Effects Satellite (CRRES), and is expected to use a satellite launched into an eccentric orbit inclined at a small angle to the equator. This will allow its sensors, which may include a selection of integrated circuit types, to experience all the particle radiation conditions to be expected from low Earth orbit to beyond the geostationary orbit in interplanetary space. Even if this mission is succesful it will not be an easy task to develop design standards for commercial satellites, for that will need an appreciation of physical conditions ranging from the microenvironment inside an integrated circuit to the conditions deep in interplanetary space, and timescales ranging from sub-microsecond interactions in digital electronics to the 22 year cycle of solar activity.

If, as is quite possible, particle-induced noise is a serious factor affecting the performance of communications satellites, are there any measures that can be taken to reduce its significance? The answer is certainly yes but the early 1990's, when this problem will first become serious, will be the worst time to seek a solution. The next period of maximum solar activity, when proton effects will be worst, will occur in the early 1990's - satellites operating then may develop high data transfer noise levels, even though for the following ten years their performance could be within specifications. So there will be demands for a quick solution to what is a fundamentally longer term geophysical problem.

As certain integrated circuits are far less susceptible to radiation effects that others, careful selection procedures even more stringent than those in use today will have to be applied to future spacecraft. Layout of spacecraft electronics will be governed by the need to prevent one cosmic ray particle from trigging errors in several integrated circuits like the plates in a nuclear research spark chamber. If all else fails the current generation of components will still be available, but their use will imply accepting a nose-dictated limit on overall spacecraft performance. Sophisticated software management will also be available, probably based on the error correcting codes already used in ground based computers and data transmission systems. But in space neither mass nor power are cheap and so the satellite operator will strive to reduce the proportion of his total computing power needed to preserve the commercial standard of data transmission.

Balancing these solutions against commercial expenditure may not be easy and compromises will have to be sustained against a background of ever-changing radiation conditions. If a satellite is designed to cope with the worst conditions that could occur a few times during the maximum of solar activity, then the capacity of a satellite will be wasted during the remaining years of its operational lifetime.

If particle-induced noise does turn out to be a limiting factor in the economics of such satellites, then the sophisticated solution would be to set up a magnetospheric weather service similar to the ionospheric weather network of ionosondes of the 1940's and 1950's that permitted the best use of high frequency radio links. Such a service, based presumably on instruments on the satellites themselves, would allow satellite operators to maximise the data throughput according to solar conditions, perhaps even on an hourly basis. Certainly such a network will be required to monitor radiation conditions if ever human beings are to be stationed in the geostationary orbit for any length of time.

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THE PROXIMITY OPERATIONS MODULE

By Gerald L. Borrowman

The prospect of repairing and servicing satellites in the Shuttle's payload bay has raised a question among satellite users who fear that sensitive instruments could be affected by the closeness of Orbiter thruster firings and water dumps. One solution would be to use a remotely-controlled unit to bring satellites into the Shuttle for servicing work to be carried out.

Introduction

One category of experiments which may be vulnerable to such contamination are those using large infrared and visible light optical systems.

So far in the Shuttle programme an Induced Environment Contamination Monitor (IECM) carried on STS2 has revealed low levels of contamination resulting from water dumps, flash evaporator operations and firings of the Reaction Control System (RCS). However, to discover the true extent of likely contamination of a satellite exposed directly to RCS exhaust plumes more measurements are needed.

RCS firings near to a satellite can increase local molecular densities as well as leaving behind particles of unburnt fuel. If such particles were to be deposited on sensitive optical sensors, solar arrays or experiment modules the performance of the equipment could be significantly altered.

Another potential hazard faced when manoeuvring close to another satellite results from the fact that the satellite's attitude control system must be turned off to ensure it will not over-ride the Shuttle's own Remote Manipulator System (RMS) motions after grappling. The satellite's drifting during this operation would make it highly susceptible to any force from the RCS exhaust plume.

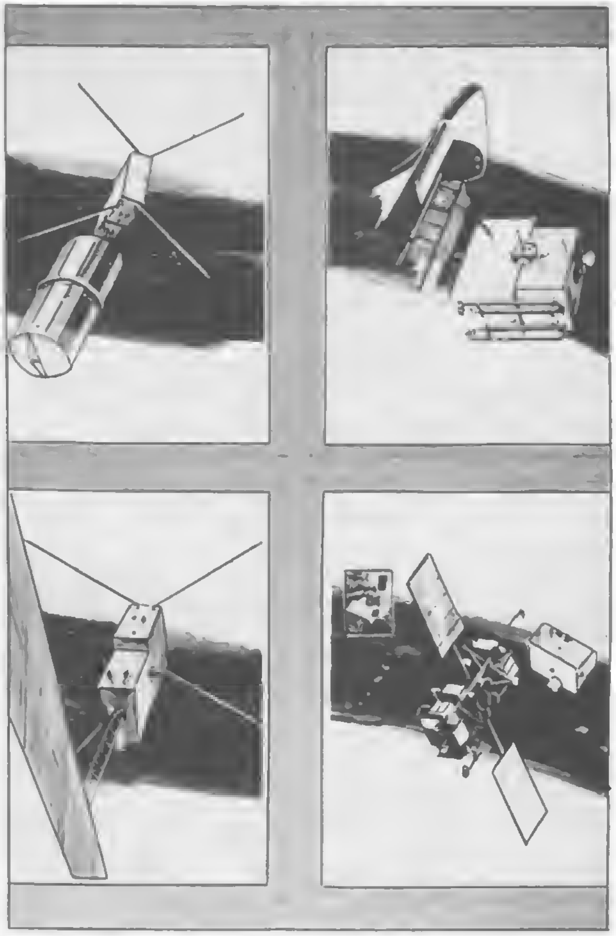
One alternative approach to bringing the Shuttle in very close to a satellite, which may also be necessary if the satellite were stabilised at a higher rotational rate than the RMS can deal with, is direct retrieval using an unmanned Proximity Operations Module (POM).

POM Configuration

Design studies envisage a free-flying POM, weighing 200 kg and measuring 112 by 74 by 90 cm, which would be despatched from the payload bay, allowing the Orbiter to "stand off" some 100 m from the target satellite.

The POM would be removed from its stowage position by the RMS ready for a crewman on the Orbiter's flight deck to use a set of hand controllers and displays to fly it to the target by remote commands. A similar flight technique to that developed during the Apollo programme for the manual terminal rendezvous and docking of the Lunar Module to the main craft would be used. The POM would bring the satellite to the immediate vicinity of the Orbiter and then release it, leaving the RMS to transfer it into the payload bay.

The modular POM would consist of an aft section containing the propulsion system, propellant and tankage, and a forward section with the electronics. In one design configuration one wall of the POM would



support power supply and distribution components as well as a 40 amp hour battery. The second POM wall would support the guidance and control systems. The "bottom" would contain the passive berthing and docking mechanisms with the front face of the POM housing the TV system together with an extendible mast and stowage canister.

Various propulsion stage sizes could be fitted to enable the POM to deal with satellites of varying size. The TV system would be used as a navigation aid during the approach and to look at the satellite's condition. To do this it would have to be capable of acquiring the target satellite in low light levels at a range of up to 1 km and provide high quality black and white pictures at ranges of 2 to 100 m.

Alternative Servicing Modes

A variety of alternatives exist for the servicing of satellites which may be sensitive to contamination from the Shuttle.

One is the Manned Maneuvering Unit (MMU), a self-contained backpack system which will allow an astronaut to work in space a considerable distance from the Orbiter. Another possibility is the use of a non-contaminating attitude control system consisting of Skylab-type Control Moment Gyros in the payload bay with cold gas thrusters and gaseous nitrogen propellant tankage mounted on extendible arms over the Orbiter's nose.

Once a satellite has been captured by the RMS equipment will be needed to help with repair work, experiment reconfiguration and consumables resupply. This task could be accomplished by a Handling and Positioning Aid, a frame and articulating arm to provide a work base for the crew. In some cases it would need to hold satellites outside the payload bay to allow solar panels or other appendages to be deployed.

STS-6: FIRST FLIGHT FOR *CHALLENGER*

By John A. Pfannerstill

The five initial flights of Shuttle Orbiter *Columbia* demonstrated the sound design of this unique space system. The sixth flight in the series introduced a new craft, *Challenger*, to the Shuttle fleet. This important mission is described in the comprehensive article below.

Introduction

As manned space flight technology moved from the age of Apollo into the era of the Space Shuttle, a 20 year old problem still remained to be solved. It was not yet possible to provide continuous tracking and communication coverage of an Earth-orbiting spacecraft.

The situation was particularly acute for the Shuttle. During a 90-minute long orbit, the spacecraft could be expected to be within range of a ground station for only a total of 35 minutes or so. Other Shuttle orbital tracks were worse, with gaps lasting a full orbit at times.

To solve the problem, an advanced communication satellite called the Tracking and Data Relay Satellite (TDRS) was developed. The huge 2270 kg, 17 m TDRS was designed to function as its named implied; that is, as a relay station between orbiting spacecraft and their control centres. Three TDRS satellites spaced roughly 120 degrees apart in geosynchronous orbit could provide full tracking coverage for the Space Shuttle at nearly all points along any orbital track. This would eventually allow expensive ground tracking stations to be phased out altogether.

The launch of the first of the TDRS satellites was the main objective of the Space Shuttle STS-6 mission [1]. Other objectives included testing of the Orbiter *Challenger*, which would be making its first flight on STS-6; scientific and technological experiments; and a repeat try at the aborted STS-5 extravehicular activity (EVA).

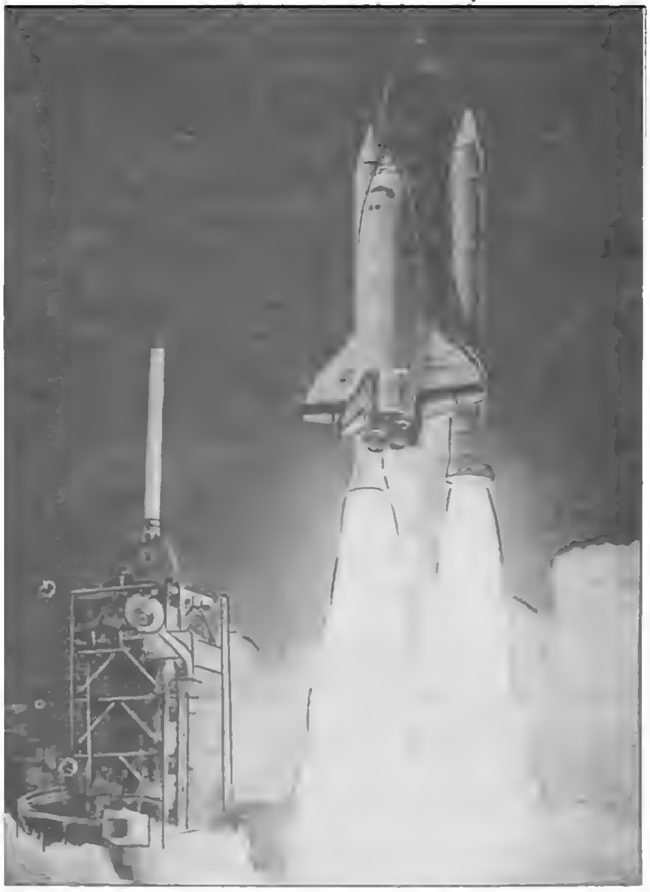
All this activity, crammed into a six-day flight, would make for a very busy mission for *Challenger's* first crew, consisting of mission commander Paul J. Weitz, pilot Karol J. Bobko, and mission specialists Donald H. Peterson and F. Story Musgrave. Weitz was a veteran of the 28-day Skylab 2 flight in 1973, but none of his crewmates had ever been in space before [2].

Challenger displayed her inexperience in pre-launch testing. The STS-6 flight had to be delayed over two months when leaks were discovered in three main engines. This pushed the launch back to early April 1983 from the original 20 January 1983 target date.

By late March, however, everything was ready to go. When the countdown got underway on 30 March 1983, things looked promising for an on-time liftoff at 18:30 GMT (all times in this report are in GMT unless otherwise stated) on 4 April.

Launch Day

As if it were trying to erase its image as a trouble-plagued problem child, *Challenger* moved through its 93-hour countdown with so few problems that "everybody was pretty bored with it," according to Lieutenant General James A. Abrahamson, the NASA Associate Administrator for Manned Space Flight. Test Director Norm Carlson, a veteran of Mercury, Gemini, Apollo and



The first launch of "Challenger" came on 4 April 1983 for the STS-6 mission.

All illustrations NASA

Skylab countdowns, said in an Easter Sunday briefing that "this is probably the smoothest countdown I have been involved with in 20 years."

But while the equipment functioned perfectly, the weather threatened to cause problems. Clear skies and warm temperatures were predicted for liftoff, but in spite of those seemingly benign conditions, weather balloons sent aloft on the night of 3 April and early on 4 April indicated the presence of unacceptably strong winds aloft in the jet stream. Winds of 116 – 122 knots were recorded in the 13,700 to 14,300 m region. The launch team remained optimistic, but they were also firm: *Challenger* would not fly unless the winds died down.

As Monday, 4 April 1983 dawned, the wind was still the major determining factor as astronauts Weitz, Bobko, Peterson and Musgrave awakened and went through the now-familiar launch day routine. As the four men were preparing for breakfast, a NASA management team went over all the latest weather data. The figures showed that the winds aloft had died down. Conditions were judged to be acceptable for launch.

Like the crew of STS-5 before them and all Shuttle crews to follow, Weitz, Bobko, Peterson and Musgrave did not wear pressure suits during the launch, wearing NASA flight suits instead. Just before entering *Challenger*, all four men put on bright orange emergency escape vests, as a precaution in the event an aborted launch caused the craft to ditch in the ocean. On their heads, they donned white Launch/Entry Helmets, which were primarily for head protection, but they also carried communication gear and a dark-tinted outer visor for use during entry.

Once the crew was aboard the Orbiter, the countdown proceeded smoothly to zero. Just 8/100 of a second after its planned 18:30:00 launch time, the Solid Rocket Boosters (SRBs) flared to life and America's second Orbiter was off on its maiden voyage.

Challenger took off into a beautiful blue cloudless sky, and launch-watchers were able to follow the craft up into the air for several minutes. Separation of the two SRBs at 2 minutes 11 seconds Mission Elapsed Time (MET), was clearly visible from the ground.

A number of factors made *Challenger*'s first launch different from *Columbia*'s five previous flights. First, the new three main engines were qualified to operate at 109 per cent of rated thrust. Although they were only to be used at 104 per cent on STS-6, this was still 4 per cent higher than the thrust levels reached on any of *Columbia*'s missions. The engines ignited on the pad at 100 per cent and then immediately after clearing the launch tower they were throttled up to 104 per cent, where they remained until Main Engine Cutoff (MECO) — except for a brief period when they were throttled back to 81 per cent during passage through the region of maxium aerodynamic pressure (Max-Q).

Secondly, *Challenger* was flying with a new lightweight External Tank (ET). Weighing in 4700 kg lighter than the STS-1 ET, it allowed nearly 4540 kg of additional payload weight to be carried aboard the Orbiter.

Thirdly, the SRB casings for STS-6 were thinner and 1800 kg lighter than those previously flown. This permitted an additional 360 kg of payload to be carried.

And finally, *Challenger* herself was a lighter weight vehicle than *Columbia*. With the addition of lighter weight thermal insulation in some areas, and the elimination of much of *Columbia*'s heavy flight test monitoring equipment, the new Orbiter was 1127 kg lighter.

All this combined to allow *Challenger* to loft the heaviest payload launched by a Shuttle. In fact, when the 21,140 kg payload weight was added to the weight of *Challenger* itself, it was the heaviest mass ever orbited by the United States on any vehicle other than a Saturn V.

Aside from a mildly depressed trajectory during the SRB stage of the boost, the launch itself was perfect. *Challenger's* engines functioned flawlessly at the stressful 104 per cent level with no signs of strain whatsoever. In fact, the only undesirable occurence during the launch was when the SRBs separated and a layer of soot was deposited on the Orbiter's windshield by the separation motors. This was annoying to the crew, but it did not seriously hamper their visibility.

Main Engine Cutoff occurred right on time at 8 minutes 20 seconds MET, followed by External Tank separation and the two standard Orbital Maneuvering System (OMS) orbit insertion burns. By 19:16, *Challenger* was in its planned 285 km circular orbit inclined at 28.5 degrees to the equator. The orbital period was 1 hour 30 minutes 22 seconds. Once the payload bay doors were opened, the crew turned on the on-board television system showing views of the folded TDRS payload attached to its Inertial Upper Stage (IUS) booster. Earth-bound viewers were able to follow as the crew examined the satellite from all angles using four television cameras in each corner of the massive payload bay. It appeared to be in excellent shape. Everything so far, as commander Paul Weitz put it, was going "tickety-boo."

The television views also disclosed two patches of nomex Flexible Reusable Surface Insulation (FRSI) hanging loose off the starboard OMS pod, apparently torn loose during the launch. The situation reminded many of the missing tiles lost from *Columbia*'s OMS pods back on STS-1. According to Ascent team Flight Director Jay Greene, however, the mission insulation would cause *Challenger* no trouble on reentry.

After completion of an initial checkout of *Challenger*, the crew turned its attention to the TDRS/IUS payload. Deployment was planned for the eighth orbit at 10 hours 1 minute MET. Although all four crewmen were involved

Paul Weitz (left) and Peterson consult a crew activity plan in the mid-deck area. Note that both astronauts wear spectacles.

to some extent, mission specialist Story Musgrave was primarily reponsible for checking out the payload and preparing it for deployment. This exacting and tedious task took much of the day.

The systems of both the TDRS and the IUS had to be checked to ensure that the stresses of launch had caused no malfunctions. Critical communications checks also had to be made, not only with Mission Control Center-Houston (MCC-H), but also with the IUS control centre at the US Air Force Satellite Control Facility in Sunnyvale, California and the TDRS control centre at White Sands, New Mexico. Everything checked out fine. Had any serious problems arisen, the payload would have been returned to Earth for repair.

At 03:53 on 5 April, 39 minutes before the scheduled deployment time, the crew was given a "GO" from all three control centres for payload deploy. The "GO" had been held up for a time because only three of the IUS' five gyros were working properly. There had been some question about whether or not to continue, but engineers at the IUS Sunnyvale control centre decided it was safe to proceed.

At 04:11, the formal pre-deploy countdown began at minus 20 minutes. Shortly thereafter, the IUS tilt table in the payload bay raised the 11 m long TDRS/IUS combination up to its 59-degree deployment position. The IUS/Orbiter umbilical was also disconnected.

The countdown reached its culmination at 04:31:58 when Musgrave actuated a switch, pushing the 18.5 tonne TDRS/IUS stack out of the payload bay at an agonizingly slow 12 cm/s. *Challenger* was flying in darkness over the Atlantic Ocean at the time, so powerful floodlights in the payload bay and a waning half Moon overhead illuminated the scene for the astronauts.

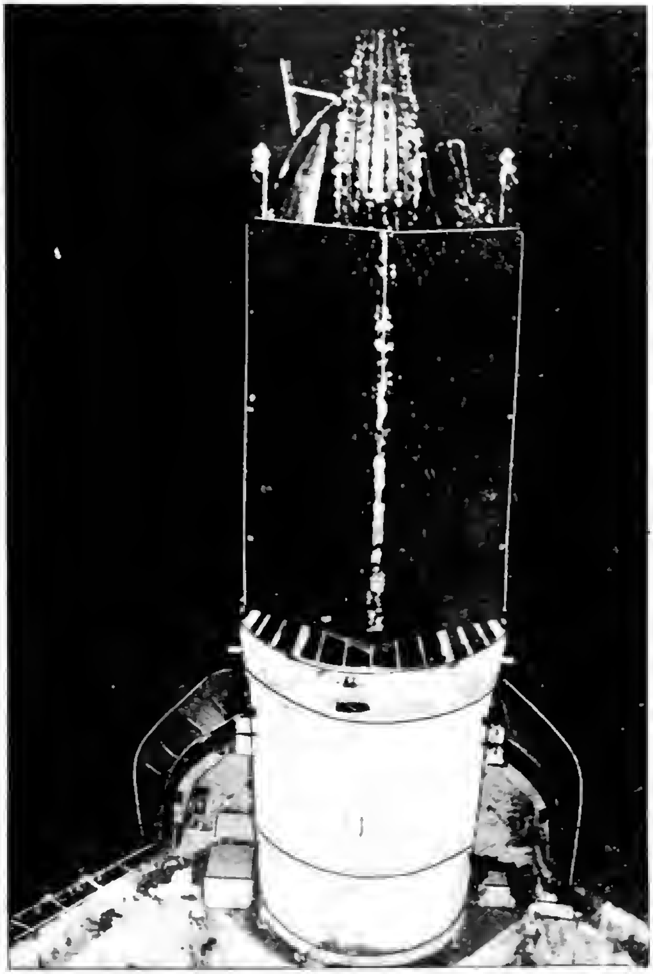
As the TDRS/IUS combination drifted slowly away, the crewmen observed it out of *Challenger*'s overhead windows. At 04:51, Weitz and Bobko fired a short 12 m/s OMS engine burn to increase the Orbiter's separation distance from the payload. *Challenger*'s orbit was changed to 328 by 287 km and separation distance from the satellite and rocket stage was increased to 59 km.

Precisely as planned, the IUS first stage engine ignited at 05:27, 55 minutes after deployment, pushing the TDRS into a geosynchronous transfer orbit. At first apogee, about 5 hours after first stage ignition, it was planned to fire the IUS second stage engine to circularise the orbit at geosynchronous altitude. From there, the TDRS would deploy it solar arrays and antennae, before separating from the IUS, and beginning a 45-day on-orbit checkout.

With the successful deployment behind them and a busy mission yet ahead, Weitz, Bobko and Peterson turned in for a well-earned rest. Musgrave had a little bit of trouble winding down after the excitement of the day, so he spent some time in the airlock doing some unscheduled checkout work on the EVA pressure suits. Finally, he too went to bed, and by 08:30, all four men appeared to be sound asleep.

Anxious ground controllers at Sunnyvale and White Sands continued to monitor the TDRS/IUS even as the astronauts slept. The $100 million satellite was the most complex communications satellite ever launched and everyone would rest easier once all the engine burns were over and the satellite was properly positioned.

Everything went as planned until 15 minutes from the time of second stage ignition. At that time, the IUS suddenly switched from its primary A computer to the backup, or B computer. There was no apparent reason at the time for the switch, but the backup system was functioning well, and the stage was committed by then to firing anyway, so controllers decided to sit tight and see what happened.



The TDRS satellite and its Inertial Upper Stage are readied for release.

At 10:45, right on schedule, the IUS second stage engine ignited. Everything seemed to be going as planned until 80 seconds into the planned 105-second firing, when all telemetry with both the TDRS and IUS was suddenly lost. The shocked flight controllers scrambled to try and find out what had gone awry and what, if anything, could be done about it.

Analysis of what little information there was indicated that the TDRS/IUS combination was tumbling out of control at a rate of about 30 revolutions per minute. There was no way to know if the apogee burn had been completed or if the TDRS had been able to separate from the IUS. Things did not look good.

The primary concern at this time was making sure the satellite was separated from the IUS. The stage's batteries were due to deplete at about 12:00, and if separation had not occurred by then, the TDRS would be forever attached to the spent stage. At 11:40, IUS controllers at Sunnyvale began sending continuous separation commands to the IUS in the hope of getting the satellite free if it were not already. Shortly thereafter, the White Sands TDRS controllers began sending commands to their spacecraft telling it to use its 24 4 N thrust attitude control jets to stop the tumble. With no telemetry coming back from space, no one had any way of knowing if the commands were taking effect.

The situation was not at all encouraging. By 13:00, with no improvement in the matter, NASA's TDRS Program Manager Robert O. Aller was beginning to make preparations for the formation of a board of inquiry to investigate what was rapidly sizing up to be a dismal failure.

But as mysteriously as they stopped, TDRS data suddenly started coming in! At 13:20, data were received

indicating that the tumble had stopped and the satellite was stabilized. The engineers were as happy as they were surprised. TDRS had, for all practical purposes, been just about given up for dead. By 13:50, White Sands was able to confirm that TDRS was free of the IUS and in the process of deploying its solar arrays, antennae and various other appendages.

The problems were far from over, however. Early tracking indicated that TDRS was in a lopsided orbit of 35,318 by 21,786 statute miles inclined at 2.37 degrees to the equator with a 16.5 hour period. Instead of orbiting in a stationary position over the equator at 56 degrees West longitude, TDRS was drifting approximately 4.5 degrees eastward each hour. In this orbit, the satellite's usefulness would be severely impaired.

Engineers quickly devised a plan to correct the situation. Over the coming weeks, they hoped to use the spacecraft's own 4 N thrust attitude control jets to move the satellite up to the proper orbit. It would be a long, drawn-out process because of the extremely low thrust of the engines. Controllers eventually managed to bring the satellite into position on 29 June after using 370 kg of propellant.

With everyone caught up in the drama of the TDRS difficulties, it was easy to lose sight of the fact that *Challenger* was performing beautifully. There were some of the minor nuisance anomalies one would expect from a spacecraft making its maiden flight, but there were no major problems whatsoever. *Challenger* was a very "clean" bird.

Mission Day 2

Challenger's four crewmen slept peacefully during the efforts to save the payload, and it was only after they had been awakened for their second day in space at 15:40 on 5 April that they first found out what had happened. MCC–H had sent up a detailed briefing over the teleprinter, which among other things, assured the men that the problem was in no way related to any negligence on their part. There did not appear to have been anything the astronauts could have spotted which would have prevented the problem.

Shifting gears from TDRS concerns, the four astronauts were charged up and ready for work. Musgrave warned MCC–H to "stand by," because "we're going to come out of the chute running hard."

The day was to be taken up mainly by scientific research activities, but before that got underway, Weitz and Bobko had to perform two engine burns. One was done with the Reaction Control System (RCS) engines, and the other with the twin 27,000 N thrust OMS engines. The burns were part of a simulated rendezvous exercise being carried out on STS–6 to practise for STS–13's planned rendezvous with the ailing Solar Maximum Mission spacecraft in 1984. Several more burns would also be conducted over the next few days as part of the exercise. After the two burns, *Challenger* was in orbit of 283 by 282 km inclined at 28.5 degrees with a 1 hour 30 minute 15 second period.

For the most part, the remainder of Day Two was taken up with science. The equipment and experiments flown on STS–6 included the following:

CONTINUOUS FLOW ELECTROPHORESIS SYSTEM (CFES) — Previously flown on the STS–4 mission, the CFES was part of a joint endeavour between the McDonnell Douglas Astronautics Company and the Ortho Pharm-

The STS-6 crew. From left: Don Peterson, Paul Weitz, Story Musgrave and Karel Bobko.

aceuticals Corporation aimed at the production and commercial marketing of space-processed medicines. The 2 m tall, 264 kg CFES was located in the Orbiter's middeck along the port side wall. The instrument used an electrical field to separate biological materials according to their individual surface electrical charge. Higher voltages were used on this flight than had been used on Mission 4 in order to produce purer samples. Among the STS-6 samples to be separated were a mixture of rat albumen and egg albumen, a mixture of normal haemoglobin, and a mixture of hemoglobin A and polysacchraide [3].

MONODISPERSE LATEX REACTOR (MLR) — A veteran of STS-3 and STS-4, the MLR was a materials processing experiment aimed at the production of perfectly formed latex spheres, all of a uniform size. On Earth, such spheres can only be produced to a size of about 3 microns in diameter. In space, it was hoped that diameters of as large as 20 microns might be achieved. The spheres were expected to be useful in the field of medicine for measuring such things as the size of pores in the walls of the human intestine. Industrial applications included the use of the spheres as size calibration standards. The MLR equipment was located in *Challenger's* middeck along the forward wall. Crew workload with the instrument was relatively light — all Musgrave or Peterson had to do was flip switches to turn the experiment on and off at desired times [4].

NIGHTTIME/DAYLIGHT OPTICAL SURVEY OF LIGHTNING (NOSL) — This experiment, which had as its objective the development of future sensors to identify severe weather from space, was previously flown on STS-2 and STS-4. The NOSL incorporated a 16 mm motion picture camera, a photocell mounted on the camera, and a two-channel stereo cassette tape recorder. During STS-6, MCC-H alerted the astronauts to possible thunderstorm activity along *Challenger's* ground track. The astronaut operating the NOSL equipment would then photograph the storm with the 16 mm camera, recording his voice comments on one channel of the tape. When the photocell detected lightning bursts, its signal was converted to an audible tone which was recorded on the other channel. Commander Paul Weitz made most of the NOSL observations.

GETAWAY SPECIAL (GAS) EXPERIMENTS — The STS-6 mission carried three GAS canisters, all of which were mounted near the forward end of the starboard longeron. The three payloads were:

1. GAS-G005 — Artificial Snow Crystal Experiment — Paid for by the Japanese newspaper Asahi Shimbun, this 0.14 m^3 $10,000 canister was designed to study the formation and structure of snow crystals formed in zero-gravity.

2. GAS-G381 — Seed Experiment — Sponsored by the George W. Park Seed Company, this 0.07 m^3 $3,000 payload was passive in nature. It carried about 10kg of fruit and vegetable seeds packed in various kinds of containers in an effort to determine the best type of packaging for the protection of seeds being carried up to future permanent space stations.

3. GAS-G049 — US Air Force Academy "Scenic Fast" (Fast meaning FAlcon Shuttle Test) — This 0.14 m^3 $10,000 canister contained five separate metallurgy and one biology experiments prepared by US Air Force Academy students. They were:

   a. Metal Beam Joiner Experiment
   b. Metal Alloy Experiment
   c. Foam Metal Experiment
   d. Metal Purification Experiment
   e. Electroplating Experiment
   f. Microbiology Experiment

As with all GAS experiments flown on the Shuttle, these were designed to require only a minimum of crew time. The only astronaut actions required were the flipping of switches of turn the experiments on and off at designated times [5].

The scientific activities, particularly the CFES, kept the astronauts busy most of the day until the last communication call of the day at 05:23 on 6 April. *Challenger*, for its part, continued to operate beautifully with only minor problems marring an otherwise perfect performance on her first flight.

Mission Day 3

Day Three was intended as a day of more scientific work with the CFES and MLR, along with suit checkout and EVA preparations tasks for the impending spacewalk on Day Four.

Telemetry data indicated that the crew was up and around by 13:17 on 6 April, but it was not until 14:29 that they received their official wake-up call from MCC-H.

The first order of the day was the third turn in the simulated rendezvous sequence. The 30 cm/s RCS manoeuvre was performed at 15:45 and left *Challenger* in an orbit of 284 by 280 km.

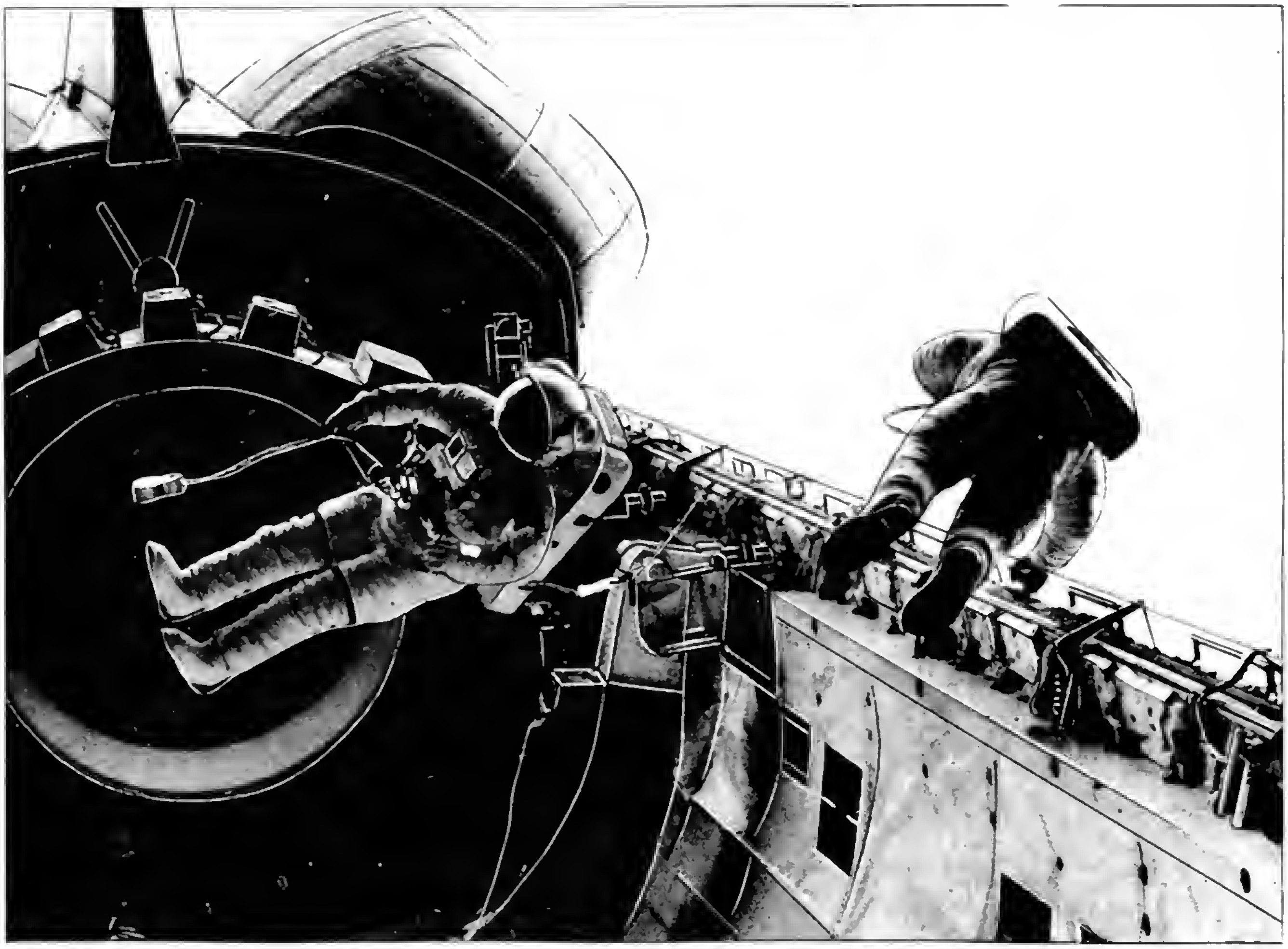
After breakfast, the men got to work on the major activities of the day. By 17:00, Peterson was getting the CFES ready for work, while Weitz photographed a line of thunderstorms over the Gulf of Mexico using the NOSL equipment. Musgrave, eager as ever for the EVA, was getting in some early, unscheduled checkout work on the space space suit upper torso section being carried on this flight, and Bobko took time out for some in-flight exercise.

At about 19:30, Weitz and Bobko began a one-hour checkout of *Challenger's* Flight Control System (FCS). This involved powering up all of the cockpit avionics to ensure proper operation, as well as the activation of one of the three Auxilliary Power Units (APUs). For the checkout, APU No. 2 was selected. It was run for only a very short time; just long enough to permit a movement check on all of the Orbiter's aerodynamic control surfaces.

During the FCS checkout, at about 20:15, live television was received in MCC-H showing pilots Weitz and Bobko hard at work on the flight deck. The view was then shifted downstairs to the middeck, where Don Peterson displayed the CFES equipment and gave viewers a brief description of the work he was doing with it.

About a half hour after the TV show, Weitz requested a private medical conference with the Flight Surgeon on duty in MCC-H, Dr. T.E. Lefton.

Under a new NASA policy, details of such conferences would no longer be made public unles the situation had a major adverse effect on the successful completion of mission objectives. The philosophy behind the decision was that a crewman's state of health was his own business — a matter between himself and his physician — and there was really no reason to disclose details of minor in-flight illneses as had been done in the past. Dr. Lefton, in consultation with Flight Director Gary Coen, determined that this was a case that fit the new policy, and accordingly, the crewman in question and the nature of his complaint were not identified.



Story Musgrave (left, identified by the bands on his legs) and Don Peterson work in the cargo bay. Note the now-empty TDRS/IUS ring behind Musgrave.

The press continued to speculate the rest of the day about which of *Challenger's* astronauts was ill, but one thing was certain: it did not appear to be Story Musgrave. The balding mission specialist seemed to have an insatiable appetite for work, particularly when it came to things related to the EVA.

At 23:00, he and Peterson began formally scheduled preparations for their EVA. Unlike STS-5, in which Joe Allen and Bill Lenoir did very little suit checkout work until the very morning their EVA was scheduled, Musgrave and Peterson conducted a complete dry run of the pre-EVA operations. Their checks included actual donning of both suits along with full suit pressurization. This was being done mainly to allow a maximum amount of time for troubleshooting in the event that problems similar to those encountered on STS-5 cropped up. None did however. The suits pressurized normally and neither Musgrave or Peterson noticed any anomalies. By 01:30 on 7 April, the two mission specialists were climbing out of the suits, primed and ready to go for the EVA.

After the evening meal and some other housekeeping chores, the crew received a final goodnight call from MCC-H at 04:38. Musgrave and Peterson, realizing that they in particular needed a good night's rest, apparently went right to bed. Weitz and Bobko stayed up a while to get some photographs of a large oil slick in the Persian Gulf, but they too soon went to sleep.

Mission Day 4

The astronauts began their fourth day in space with a symbolic touch of nostalgia. MCC-H played the theme music from the old television series "F-Troop" (as the sixth crew, they were tagged with the sixth letter of the alphabet) to wake the crew up at 13:20 on 7 April [6]. For the most part, day four was taken up entirely with preparations for the EVA, the EVA itself, and cleanup afterwards.

Mission Specialists Don Peterson and Story Musgrave were excited about their space walk. Largely because of Musgrave's unplanned advance preparations, the men found themselves way ahead of the timeline. At 14:57, Weitz asked for and received permission to start the EVA as much as one hour early and, for a while, it seemed as though Musgrave and Peterson might do just that. But as preparations wore on, it appeared that they would start their walk closer to the 21:10 time it was scheduled to begin after all.

Suit donning began at about 16:30. The two spacewalkers were assisted in the airlock by Bobko. Each man put on his trouser section before sliding up into the hard upper torso section of the suit mounted on the airlock wall. Each then locked the two suit segments together by a ring at the waist.

By 17:00, the men had their helmets and gloves on and were ready to conduct a leak check on the suits before purging them with pure oxygen to flush out all of the Orbiter's ambient air atmosphere. They were then able to begin, starting at 17:23, a 3.5-hour pre-breathe period to eliminate all of the excess nitrogen from their bloodstreams. This was done to avoid the spaceman's version of a deep sea diver's affliction known as the "bends."

During the long pre-breathe, Musgrave and Peterson simply hung on the wall of the airlock, all sealed up in their suits, with nothing to do. Weitz and Bobko had work to do, however. While their partners either napped or

daydreamed, they had air filters to clean and other housekeeping jobs to perform.

At 20:53, the pre-breathe was completed, and at 21:03 both suits were disconnected from Orbiter power to begin using consumables from their backpacks. From this point, the airlock was vented down to zero and the hatch to the payload bay was opened.

All this took place while *Challenger* was out of contact with the ground. When it moved into range of the Guam tracking station on Orbit No. 51, MCC–H received the report that the hatch was open and Musgrave was halfway out. Peterson was still inside. The time was 21:21. Five minutes later, Peterson too was outside, and the spacewalk was underway.

The plans for Musgrave and Peterson's EVA was essentially the same as that planned for Joe Allen and Bill Lenoir on STS–5. There were some minor changes brought about by the differing payload bay configurations between the two flights but, in essence, the main purpose of the EVA remained that of spending several hours in the new EVA suit to see how well it worked.

The Shuttle suits used no umbilical lines. The life support system was completely self-contained in the backpack. Neither was there a rigidly attached safety tether. Instead, the suits had new tape-like portable tethers on spring-loaded reels which could be attached at different points in the payload bay to increase astronaut mobility. Each man had two such tethers, so that when he was shifting one of them to a new attachment point he would still be safely secured by the other.

One of the first activities involved Musgrave clipping one of his tethers to a slide wire running the full length of the payload bay. There were two such wires, one on each payload bay door hinge line. Musgrave attached his tether to the starboard slide wire and, using handrails mounted on the hingeline, he made his way back to the aft end of the bay. Peterson remained at the forward end to monitor his partner's progress.

By this time, at 21:38, the first live television of the activity was being received in MCC–H, relayed through the Hawaii tracking station. Spectacular pictures were received from the colour cameras mounted in each corner of the payload bay. *Challenger* was "upside down," and the cloud-spattered Earth formed a blue and white ceiling overhead for the men as they worked. For most of the EVA, Musgrave left his gold-coated Sun visor up, so television viewers could frequently see his face through his helmet visor. Waving to the camera at one point, his broad smile displayed his obvious delight. The astronauts seemed to thoroughly enjoy EVA.

At one point, capcom astronaut Jon McBride asked, "How does this compare to the water tank, Story?" [7].

"Well, there's no viscosity," he answered. "If you get (something) going, you can keep it going. (Also) this is a little deeper pool than I'm used to working in."

Once Musgrave arrived at the aft starboard corner of the bay, he used handrails mounted on the aft bulkhead to move over to the aft port corner. Peterson meanwhile clipped one of his tethers to the port side slide wire and translated back to the aft end to join his companion. The purpose of all the slide wire activity was mainly to evaluate long-distance mobility in the new suits. There seemed to be no problem whatsoever.

Musgrave and Peterson then made their way back down the slide wire to the forward end of the payload bay. Musgrave stopped halfway to conduct an experiment known as the Tether Dynamics Exercise. He attached one of his tethers to a port handrail and the other to the starboard slide wire. He then let the 4 N tension force on his tether reel pull him slowly toward the centre of the payload bay. This left him suspended in the centre of the bay, with a tether securing him to each side. The purpose of the exercise was to see how well the two-tether suspension would hold an astronaut in place for a task in the centre of the payload bay. It seemed to work well.

At the forward end of the payload bay, the two spacewalkers spent some time working at a tool box near the starboard corner. They unstowed various tools, evaluating how difficult it was to manage the individually tethered tools in zero-g, a task which could at times be a challenge. The astronauts also checked out foot restraints and their reach capability in the suits at the same time.

Thus far, nearly two hours into the planned 3.5-hour EVA, the new suits were performing beautifully. The only problem with them, the men noted, was that in direct sunlight, they found it impossible to read the Light Emitting Diode displays on the chest-mounted suit control unit. The sunlight washed the displays out.

The next activity on the agenda for Musgrave and Peterson was probably the most strenuous. It was an exercise to stimulate procedures for lowering a balky IUS tilt table stuck in a poition unsuitable for payload bay door closing. Plans for such an emergency call for the table to be winched back down into a stowed position using a series of ropes and pulleys and a winch crank mounted on the aft payload bay bulkhead. The STS–6 table was already in the stowed position, so the crewmen did not try to move it. They did, however, set up the proper rope and pulley configuration they would need to have had it been necessary.

After the IUS exercise, the astronauts performed a similar operation at the forward bulkhead. This time they were simulating procedures for winching the payload bay doors closed in an emergency. Once again, they did not actually close the doors, but merely set up the proper rope and pulley configuration. They used an "Exergenie" exercise device to put a load on the rope, and Musgrave tried cranking the winch to see how difficult it was. He used a portable foot restraint mounted on the forward bulkhead. Although the winching was hard work, he found it to be much easier when he used the restraint than he did using no foothold whatsoever, which he also tried.

Once the door winch operations were completed, the men evaluated the Payload Retention Device. This was a ratchet-like device that could be used in an emergency to secure loose pieces of cargo in the payload bay which for one reason or another could not be secured normally for entry and landing. It was standard equipment on all Shuttle flights, as were all the tools, ropes, pulleys and winches the men had evaluated previously. It was good to see that all the contingency EVA equipment actually worked in space.

The final task for Musgrave and Peterson before going back inside was what was called the "Massive Article Translation." For this test, Musgrave carried a bag containing about 15 kg of tools down the starboard slide wire to the back of the payload bay. Then he moved across the aft bulkhead to the port slide wire before moving back up the port side to the forward bulkhead. The purpose was to evaluate how easy or difficult it would be for an EVA crewman to move a large object of considerable mass from one place to another in the payload bay. Musgrave seemed to have no trouble.

By the time *Challenger* came up over Hawaii on Orbit No. 53, the EVA was in its final stages. Live television was being received showing the astronauts stowing away the last of their tools, ropes and other equipment.

At 00:50, viewers could see Peterson slide back through the airlock hatch feet first. Musgrave followed at 00:53, ending the first EVA of the Shuttle programme, and the first in over nine years for American astronauts. Story Musgrave had been outside for 3 hours and 32

minutes, and Don Peterson just eight minutes less. Their EVA had gone extremely well.

There were some difficulties re-pressurizing the airlock until someone noticed that one of the dump valves had been left open from the depress cycle. The valve was closed and the pressure came back up normally.

Musgrave and Peterson got out of the suits they had been in for nearly ten hours and immediately began re-charging the back-packs. This was being done in case they would have to go back outside later in the flight to take care of a real emergency.

Weitz and Bobko meanwhile performed the fourth rendezvous phasing manoeuvre, which was a 30-second RCS burn at 02:53. The retrograde firing changed *Challenger's* orbit to 284 by 274 Km.

The men were tired from the events of the day. MCC-H talked to them for the final time at 03:53, and by 04:47, telemetry indicated that all systems were secured for the night and everyone was asleep. It had been a very successful day.

Mission Day 5

The last full day in space for the STS-6 astronauts began a little on the slow side. After playing wake-up music at 12:30 on 8 April, capcom astronaut Mary Cleave had to call the crew four times before they responded. The day was to be a relaxed one, so a little slugishness was forgiveable. Most of the day was to be spent packing things away and preparing *Challenger* for her entry and landing on Day 6.

In addition to the programmed activities, there was also some unplanned stowage work to take care of. During the launch, about one minute into the flight, all four men heard a loud cracking sound behind them in the cockpit. Once in orbit and a couple of days later, they finally located its source. A bracket holding two 18 kg television monitors at the aft payload control station had broken under the launch strain. MCC-H prudently decided that it would be unwise to enter the atmosphere with the monitors flopping about, so Peterson was given instructions to disconnect them, wrap them up in pillows and tape, and secure them to the middeck floor.

As they continued with their other stowage work, the astronauts were plagued by the "jack-in-the-box effect," a common zero-g occurrence which sends everything flying out of a locker the moment its door is opened. To put an item away, the men often had to round up everything else that had escaped while the door was open. This made the job a little more time consuming.

Shortly after 18:00, MCC-H received a distinguished visitor, Vice President George Bush. He was there to have a lunch-time chat with the crew. The four astronauts lined up in front of the middeck television camera, all of them wearing glasses, which led to jokes about the crew's "advanced" age (Weitz was 50, Bobko 45, Musgrave 47 and Peterson 49 at the time of the STS-6 mission). "This programme has been brought to you by the Geritol Bunch," said Weitz as a sign proclaiming "111 years of aviation experience" was held up to the camera. There was other clowning around as well as the irrepressible Dr. Musgrave turned effortless zero-g somersaults.

Like all space travellers on short duration missions, the "Geritol Bunch" was not looking forward to coming home, and it was with some reluctance that they completed their preparations for entry.

By bedtime, *Challenger* was basically ready to go. She was all cleaned up, Weitz and Bobko had the cockpit cue cards taped up around the instrument panel and their entry checklist books out, all set for the landing. MCC-H bade the crew goodnight at 02:30 on 9 April.

As the astronauts were just settling down for sleep, an alarm sounded notifying them of the failure of General Purpose Computer (GPC) Number 2. When they were next over a ground station, commander Paul Weitz told MCC-H of the problem. He was instructed to "dump" the GPC-2 software to the ground and power down the computer. Once this was accomplished, the crew finally got back to sleep at around 04:30.

Engineers on Flight Director Randy Stone's Planning Team spent most of the night studying GPC-2's software load and hardware configuration in an effort to determine what had gone wrong. The failure was a major one but, paradoxically, it was not critical. GPC-2 was one of four identical "Redundant Set" computers, each loaded with identical software. Any one of these computers would be sufficient to fly the entire mission. Three good ones were still available. In addition, there was a fifth backup computer aboard loaded with similar but different software. This computer was also capable of flying the entire mission by itself, but it would be called upon only if a problem common to all four primary computers were to knock out the entire set. Controllers expected no problems at all in flying *Challenger's* first landing on the three remaining GPCs.

Mission Day 6

The astronauts were awakened at 11:04 on 9 April after their final night in orbit.

Things looked very good for the upcoming landing. The weather at the Edwards Air Force Base, California landing site was predicted to be excellent with scattered clouds at 8,000 m and surface winds out of the southwest at 12 knots.

By 14:30, astronaut John Young was aloft in NASA-903, a T-38 jet aircraft, surveying the weather first hand. He reported no clouds at all from Santa Barbara, where *Challenger* was expected to first cross the California coast, all the way in to Edwards.

Up in orbit, the four crewmen were getting *Challenger* ready for entry. The payload bay doors were "all zipped up" (to quote Weitz) by 14:50 and shortly thereafter the final Inertial Measurement Unit (IMU) alignment was made.

At 16:26, with roughly an hour and a half to go until the deorbit burn, Weitz reported, "We feel we're ready in all respects." The crew donned their escape vests, put their helmets on, and got themselves strapped into their seats. *Challenger* was set to come home.

By this time, Young was back in the air over Edwards. Now he was flying NASA-946, one of the two modified Grumman Gulfstream-2 Shuttle Training Aircraft (STA) [8]. His purpose this time was to fly approaches to the runway to check on winds, turbulence and any other factors he felt Weitz should know about before the Orbiter's landing. Runway 22, the main concrete runway at Edwards, was chosen for the STS-6 landing because recent rains had in fact flooded the normally dry Rogers Lake Bed.

At 17:27, while passing over the Dakar, Senegal tracking station on Orbit No. 80, *Challenger's* crew was given a "GO" for the deorbit manoeuvre. The 2 minute 2 second burn on both OMS engines was initiated over the Indian Ocean at 17:55:00. It decreased the Orbiter's velocity by 89 m/s starting it on its long glide halfway around the world to Edwards.

A pass over the Yarragadee, Australia station at 18:01 confirmed that the deorbit burn had been perfect and that *Challenger* was right on target. Weitz said that just before firing the deorbit burn, he "gave everybody a last vote at 30 seconds (to see) if they didn't want to go around one

more time and all I got was a blank look. Nobody wanted to do that."

Capcom astronaut Roy Bridges replied, "Maybe we can get you another flight real soon. I think that's a better way to go."

This was the last communication with *Challenger's* crew until the Orbiter came out of the entry blackout near the coast of California, and Bridges bade them farewell saying, "We're looking forward to F-Troop coming over the hill at Buckhorn (California) in about 30 minutes."

Challenger hit the first tenuous layers of the Earth's atmosphere at an altitude of 127,000 m at 18:23:27. She was travelling 7,437 m/s at a range of 7,490 km from Edwards.

In addition to the four standard roll reversals performed on all Shuttle reentries to bleed off energy and fine-tune the guidance, pilots Weitz and Bobko also performed a series of manoeuvres during the entry. Called Programmed Test Inputs (PTIs), they were designed to check out aerosurface effectiveness at various points in the entry.

The first PTI was performed at an altitude of 79,000 m. It consisted of a right aileron pulse followed by a right roll jet and then a right yaw jet input. There were eight more similar manoeuvers flown at different times, all designed to fully evaluate the manoeuvrability of the new Orbiter.

By 18:41, *Challenger* was across the Pacific and back once again in contact with MCC-H. She was at an altitude of 51,320 m and 769 km uprange of Edwards. By 18:48, the Orbiter was visible as a tiny triangular object on the television screens in MCC-H. As the vehicle got closer to the landing area, the T-38 chase aircraft caught up with it and striking television was obtained as *Challenger* passed directly over Edwards before making a wide, sweeping 200-degree left turn onto her final approach path.

To test the autoland system, Weitz left *Challenger* in the automatic mode until about 1,500 m in altitude. He then took over manual control to land the vehicle himself.

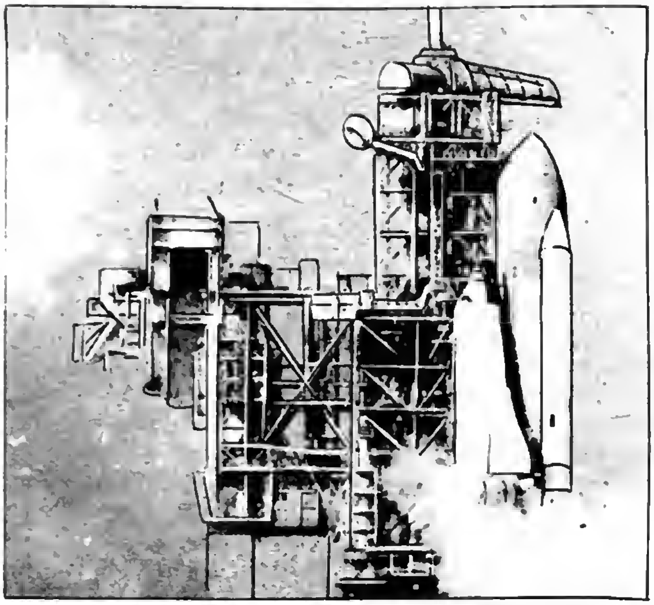
As he flew the craft, he had the benefit for the first time of the Head-Up Display (HUD). This was a special optical system, already installed in most US jet fighters, which actually projects flight instrument readings onto the windshield, thereby allowing the pilot to keep track of his altitude, velocity and attitude without taking his eyes away from the scene outside. *Columbia* did not have the HUD on her first five flights.

Weitz lined *Challenger* up perfectly with the end of Runway 22. As thousands watched, the Orbiter touched down smoothly, the rear landing gear wheels kicking up a brief puff of smoke at 18:53:42. The nose gear came down shortly thereafter and the vehicle rolled over 2,100 m before coming to a stop. "Full halt. Troop prepare to dismount," Weitz called to his crew in the best F-Troop tradition. *Challenger* was home. Flight time was 5 days 0 hours 23 minutes 42 seconds.

Aftermath

When *Challenger* was given its first post-landing checkout at Edwards, engineers and technicians were surprised to find it in excellent condition. The new Orbiter was in much better shape than *Columbia* had been in after returning from any of its flights. *Challenger* had suffered only 22 anomalies during its first flight. By contrast, *Columbia* had had 82 during its maiden voyage.

A quick check of *Challenger's* exterior revealed only one chipped thermal tile out of the thousands covering the aircraft's outer surface. There were however, several missing or shredded sheets of Advanced Flexible Reusable Surface Insulation (AFRSI) on the OMS pods. This was not terribly serious, but after seeing what happened to the AFRSI, engineers were considering replacing the quilted fabric material with conventional tiles for STS-7. On the whole, however, *Challenger* was very clean.



"Challenger's" engines were tested on the pad to qualify them for the flight.

This was a good omen. For in order to meet the very demanding turnaround schedule required to get *Challenger* ready for Mission 7 in early June 1983, the less repair work engineers had to contend with, the better.

REFERENCES & NOTES

1. At the time the STS-6 mission was launched, it was planned to launch the second TDRS satellite on Shuttle Mission 8 in August 1983, and the third on Mission 12 in March 1984. The subsequent problems with TDRS-A's deployment on STS-6 however has since forced a revision of the schedule. TDRS-B was pushed back from STS-8 to STS-12 to allow more time for evaluation of the problems encountered.
2. For detailed biographical sketches of the STS-6 crew-membes, see "Space Report" in *Spaceflight*, January 1983.
3. Detailed information on the CFES, prepared in advance of the STS-4 mission, is available in *Aviation Week and Space Technology*, 31 May, 1982, pages 51-57.
4. An excellent article on the MLR appears in *Spaceflight*, November 1982, pp. 396-397.
5. Additional information on the GAS programme is contained in the article "Getaway Specials" by Chester M. Lee. It appears in *Spaceflight*, May 1979, pp. 197-202.
6. Weitz, Bobko, Musgrave and Peterson, being the sixth Shuttle crew, had always been referred to as the "F-Crew" in mission planning documents. (STS-1's Young and Crippen had been the "A-Crew," Engle and Truly of STS-2 were the "B-Crew," and so on down to "F"). Someone had picked up on the "F-Troop" idea somewhere along the line, and the STS-6 crew adopted the theme of the old Civil War situation comedy as their unofficial designation. In addition to their official crew portrait (seen on pp. 264 and 265 of *Spaceflight* for June 1983), the astronauts had an identical picture of them taken in which they wore Civil War Union Army uniforms as a joke. Throughout the STS-6 mission, there were many references to the "F-Troop" theme.
7. For a first-hand idea of EVA training underwater, see John Bird's article "Training Below for Work Above" in *Spaceflight*, February 1983, pp. 61-63.
8. Details on the Shuttle Training Aircraft can be found in *Aviation Week and Space Technology*, June 6, 1983, pp. 65-82.

BE A PART OF MAN'S JOURNEY INTO THE COSMOS

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16-18 November 1984

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Yes, please send me a Registration Form and further details on Space '84.

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SPACE '84

SATELLITE DIGEST–169

Robert D. Christy
Continued from the December issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

NAVSTAR 8 1983-72A, 14189

Launched: 1020, 14 Jul 1983 from Cape Canaveral AF8 by Atlas F.
Spacecraft data: 8ox-shaped structure, approx 2 m each side with two solar panels, mass around 800 kg.
Mission: Operational 8lock 1 satellite in the US Global Positioning System. Navstar 8 is the seventh to reach orbit; the previous launch on 18 Dec 1982 failed when the launch malfunctioned at lift off.
Orbit: 19952 x 20798 km, 725.78 min, 62.84 deg.

MOLNIYA-1(57) 1983-73A, 14199

Launched: 1520, 19 Jul 1983 from Plesetsk by A-2-e.
Spacecraft data: Cylindrical body housing instruments and the payload, surmounted by a conical motor section, power is provided by a 'windmill' of six solar panels. Overall length is 3.4 m, diameter 1.6 m and mass around 1800 kg.
Mission: Communications satellite helping to operate long distance telephone and telegraph communications, and broadcasting of Central TV programmes to Orbit receiving stations in the Soviet far north, the Soviet far east and central Asia.
Orbit: Injected from a low, parking orbit into an elliptical one of 459 x 39024 km, 699.96 min, 62.94 deg. Later raised to 718 min to ensure daily ground track repeats.

COSMOS 1484 1983-74A, 14204

Launched: 0800, 20 Jul 1983 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length is about 6 m, maximum diameter 2.4 m and mass around 6000 kg.
Mission: Photographic reconnaissance, all or part of the payload was an Earth resources package. Recovered after 14 days.
Orbit: 260 x275 km, 89.88 min, 82.32 deg.

COSMOS 1483 1983-75A, 14207

Launched: 0600, 25 Jul 1983 from Tyuratam by A-1.
Spacecraft data: Cylindrical body with two Sun-seeking solar panels. Length about 5 m, diameter about 1.5 m and mass around 2200 kg. Sensing equipment similar to that on the Meteor 2 satellites is located at one end.
Mission: Earth resources sensing and testing new remote sensing equipment.
Orbit: 593 x 664 km, 97.31 min, 98.01 deg.

COSMOS 1485 1983-76A, 14210

Launched: 1200, 26 Jul 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1483.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 358 x 415 km, 92.30 min, 72.85 deg.

TELSTAR 301 1983-77A, 14234

Launched: 2250, 28 Jul 1983 from Cape Canaveral by Delta 3920/PAM.
Spacecraft data: Standard Hughes HS376 design of a 2.16 diameter cylinder, 2.77 m long and extending to 6.83 m after deployment of drum-shaped solar panel extension. The mass is 1225 kg, including 572 kg of fuel.
Mission: To carry commercial communications channels for the American Telephone and Telegraph Company. The satellite is the first in a series of three designed to replace the Comstar satellites leased by AT&T from the Communications Satellite Corporation.
Orbit: Geosynchronous, initially above 66 deg west longitude for testing, and later to be moved to its operational location of 96 deg west.

SDS 8 1983-78A, 14237

Launched: 31 Jul 1983 by Titan 38-Agena D.
Spacecraft data: Not available.
Mission: Military communications, particularly in polar regions.
Orbit: Possibly similar to the Molniya communications satellites.

COSMOS 1486 1983-79A, 14240

Launched: 1245, 3 Aug 1983 by C-1 from Plesetsk.
Spacecraft data: Possibly a cylindrical body with domed ends, and enclosed in a drum-shaped solar array with length and diameter both about 2 m. The mass may be about 700 kg.
Mission: Military communications using a store/dump technique.
Orbit: 784 x 806 kg, 100.78 min, 74.05 deg.

COSMOS 1487 1983-80A, 14245

Launched: 0920, 5 Aug 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1483.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package. Recovered after 14 days.
Orbit 261 x 275 km, 89.89 min, 82.31 deg.

SAKURA 2B 1983-81A, 14248

Launched: 2030, 5 Aug 1983 from Tanegashima Space Centre by NII.
Spacecraft data: Cylindrical, spin stabilised spacecraft enclosed in a drum-shaped solar panel with de-spun antenna and reflector. Length 2.05 m (3.29 m incl. antenna), diameter 2.18 m and mass 670 kg at launch including 355 kg of fuel and tank pressurant.
Mission: Communications links include telephone, TV and data with uplinks in the range 27.5 to 29.25 GHz and downlinks between 17.7 and 19.45 GHz used by stations on the Japanese mainland. There are also two C-band channels (uplink 5.925 to 6.425 GHz and downlink 3.7 to 4.3 GHz) for communications between the main islands and remote islands of the group.
Orbit: Geosynchronous above 135 deg east longitude.

COSMOS 1488 1983-82A, 14251

Launched: 1130, 9 Aug 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1483.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 356 x 415 km, 92.27 min, 72.86 deg.

COSMOS 1489 1983-83A, 14256

Launched: 1300, 10 Aug 1983 from Tyuratam by A-2.
Spacecraft data: Possibly as Cosmos 1483.
Mission: Military photo-reconnaissance, recovered or decayed.
Orbit: 171 x 365 km, 89.85 min, 64.72 deg, recoverable.

COSMOS 1490-1492 1983-84A-C, 14258-14260

Launched: 1830, 10 Aug 1983 from Tyuratam by D-1-E.
Spacecraft data: Not available, but each satellite may be similar to Cosmos 1486.
Mission: Second launch of three satellites into USSR's GLONASS navigation satellite system.
Orbit: Initially a low one at 51.6 deg inclination and then via an elliptical transfer orbit to approx 19100 x 19200 km, 676 min, 64.9 deg.

PROGRESS 17 1983-85A, 14283

Launched: 1208*, 17 Aug 1983 from Tyuratam by A-2.
Spacecraft data: Similar in appearance to Soyuz-T except that the re-entry module is replaced by a cone-shaped, non-recoverable module for stores.
Mission: To carry consumables and experimental materials to the crew aboard Salyut 7. Progress 17 docked with Salyut's rear port at 1347, 19 Aug 1983. It undocked and re-entered the Earth's atmosphere one month later.
Orbit: 319 x 339 km, 91.05 min, 51.61 deg (after docking).

THE 38TH ANNUAL GENERAL MEETING

In the Chair: Mr. A.T. Lawton, *President*.

In attendance: *Members of the Council,* Mr. G.V. Thompson, Professor G.V. Groves, Mr. G.J.N. Smith, Dr. A.R. Martin, Mr. C.R. Turner, Dr. L.R. Shepherd, Mr. C. Childs, Mr. G. Webb, Mr. T.J. Grant; and about twenty members.

Presidential Address

The President began by saying that the Report of the Council, besides being the first he had prepared, was probably also one of the easiest a President had ever had to write. Out Society is now chalking up a total of 50 years of continuing achievements, so one of the most encouraging remarks he had heard, that morning, was to the effect that the Society looked likely to continue in the same way for at least another 50 years!

Space '82 called for particular mention. Apart from its undoubted success and the many letters of appreciation received afterwards, the opportunity had been one on which NASA had presented the Society with a special plaque, an extremely generous gesture and one for which we are all really most thankful.

This plaque, which the President then displayed, now has an honoured place in the Society's HQ.

Balance Sheet and Accounts

The Executive Secretary introduced the accounts and drew attention to the main features. In particular, the Society's indebtedness stemming from the acquisition of the HQ building had now been fully paid off though the total surplus for the year was less than 3 per cent of total income. This was cause for some concern for, realistically, the target should be of the order of 12–15 per cent.

A slight increase in income has taken place but this had been wholly absorbed by increased publication costs. The Society had taken the opportunity to begin to renew some of its equipment, the old equipment being written off. This would be necessary for several more years, hence our need to obtain gifts, donations or an increased membership base to enable it to be done.

The President added that, although short of money, the Society was not short of skill and enthusiasm. A Membership Drive was clearly essential, not only to assist us now, but to develop plans for the future.

The accounts were approved.

Council Elections

After the re-election of the auditors the President then read the names of five candidates who had offered themselves for election to the Council. Since there were only four vacancies, election would be by postal ballot in the usual manner with 31 January 1984 as the final date for the return of the ballot papers.

Any Other Business

With formal business concluded, various questions were then dealt with, e.g. concerning the interest of the Society in replacing its film service with a video service, detailed matters concerning type-faces, frequency and scope of Society magazines, and how these might be extended still more, assuming that sufficient staffing and funding was assured.

Discussion ended with the President pointing out that the Council was now actively involved in marketing the image of the Society with the aim of increasing its financial base through increased membership and other means. If every existing member helped by introducing one new member, our total membership would be doubled and the scale of our financial operations altered immeasurably. Each new member introduced is worth about £8 to the Society, for this is the cost which would otherwise have to be paid in advertising, etc. to secure the same result. An enhanced growth will actively decrease the pressure for subscription rates to rise, so this is a matter of direct and immediate interest to every member.

The meeting concluded with a Vote of Thanks to the Society's Council.

Astronomy: The Cosmic Perspective
M. Zeilik & J. Gaustad, Harper & Row, 954pp, 1983, £29.

This is one of those books which everyone genuinely interested in learning about astronomy ought to have. It is a text book, yet one ideally suited for self-study and with a wealth of information cogently and clearly presented. At the end of each chapter there is a summary, review questions, problems for solution and references. Additionally, there are a number of appendices containing astronomical data, thus making the whole a book which can easily be picked up by teachers and used as a source-book for lessons, though it should be pointed out that some knowlege of mathematics is required for a number of the chapters.

The volume is divided into five main sections: an introduction to concepts of the Universe, the birth of cosmological models, the growth of the Sun-centred ideas and then, moving outwards, the question of stellar evolution and formation of planetary systems. The last two sections deal with galaxies and cosmic speculation, respectively, the latter including a considerable amount of information about the nature of life.

A good deal of ancillary information is contained under these main headings. For example, telescopic and other observational techniques are summarised, the contributions of Galileo, Newton and Einstein, among many others, summarised, and much updated information provided on pulsars, black holes and the like. SETI and CETI are both introduced towards the end, the final thoughts being concerned with the future of the Universe, our Galaxy, the Earth-Sun system and, finally, ourselves. This last points out, rather grimly, that if we do not achieve a stable population there will be no choice but to leave Earth. The problem here is one of exponential growth for, in the lifetimes of most of us, the number of people currently alive will exceed the total of those who have ever lived before. The future course seems clear. Manipulation of energy sources is essential, for this holds the key to all of Mankind's aspirations.

Stellar Paths
P. van de Kamp, D. Reidel Publishing Co., 135pp, 1983, $34.50.

Long focal-length astrometry, repeated over the years, yields the apparent motions of observable stars with remarkable precision. Double and multiple star systems are, of course, used for mass determination but distances are determined from parallaxes. In this book the author shows how, by prolonging the period of observation, data can be improved so that proper accelerations as well as proper motions can be determined. The

result is that a volume a thousand times greater than the present sphere of a few hundred parsecs surrounding the Sun can thus be explored. However, problems arise because the objects studied may be too faint or their proper motions too small. There ere elso difficulties in defining an absolute system of reference.

Thus, a complete understanding of galactic dynamics becomes indispensable, together with a detailed study of the complex rotation of our Galaxy.

On this work the author included his proof of the existence of visible bodies but are they planetary or faint steller compenions?

A good example is the chapter on Bernards' Star, not least because this was the object chosen for the BIS Daedalus star probe study. This smell star is, still, the one with the largest known proper motion. It was discovered by Barnard in June 1916 end shortly afterwards was dubbed the "runaway star." It was soon recognised as the nearest known star next to the Alpha Centeuri system with a distance which is gradually diminishing from the present value of six light years to a minimum of just under four light years around A.D. 11800. By then its apparent visual magnitude of 9.5 will have increased to 8.5. Evidence appeared in 1956 which disclosed perturbations with a period of something like 20 yeers. Ever since, continuing observations have sought to provide a basis for calculeting the orbit(s) of the invisible companion(s).

Astrophysical Jets

Eds. A. Ferrari & A.G. Pacholczyk, D. Reidel Publishing Co, 327pp, 1983, $48.

Recent high-resolution observations at various frequencies (radio, optical, X-ray) heve revealed that, in in many cases, active astrophysical objects, from stellar-sized sources to galactic nuclei, eject supersonic (eventually relativistic) flows. These flows involve a substantial fraction of the globel energies of their sources.

Although the study of the physical processes which produce "jets," and support them in their rich morphological forms over extended regions for long lifetimes is still at an early stage, meny proposals and experimental tests are being actively pursued to try to reach a better understending of the phenomenon.

The processes in jets clearly depend on complex plasma phenomena. The continuous outflow (beams or jets) of energy, mass and momentum wes first postulated about ten years ago. Jets show a wide variety of structures which probably provide clues to differing physical processes which are responsible for them.

The Torino Workshop on Astrophysical Jets was organized to provide e specific opportunity of these discussions. Important contributions heve been collected in these Proceedings and given an updated picture of the main topics of interest in the field, as well es e stete-of-the-art surveys to the end of 1982.

Glimpsing an Invisible Universe

R.F. Hirsh, Cambridge University Press, 186pp, £20.00.

This book deals with the evolution of X-ray astronomy during its initial phases. The story begins in the late 1950's with the discovery of high-energy radiations coming from beyond the Solar System end is teken to the point et which X-ray astronomers started to explore questions of broader astronomical interest. During this early period, when fundamental data end the rudiments of theory began to emerge, three important transformations in astronomical practices occurred. First was the augmentetion of purely optical observetions; second was the eppeerence of government funding as a major source of financial support and, thirdly, the greet alterations to the size, structure and organisetion of research which followed the introduction of govemment money.

The result is a volume which goes beyond the emergence of X-ray astronomy as a scientific discipline: it deals also with changes in public policy, still continuing, and have brought this end much similer work more closely into the government orbit.

Guidance and Control 1983

Eds. E.J. Beuman and Z.W. Emsley, American Astronautical Society, 1983, 480pp.

This is Vol. 51 in the long-running series issued by the Americen Astronautical Society under the theme of "Advances in the Astroneutical Sciences." It updates other volumes on the same theme for previous years.

The book is divided into five mein parts i.e. precision pointing end tracking; technical storyboard display; trends in autonomous systems; stabilizing the space station and recent experiences.

Since e total of 33 papers are listed it is impossible to do more than mention e few. Particularly interesting are those which deal with the requirements for space stations, both for long-term control in orbit and for attitude stability. Several papers deal with the Shuttle and others with concepts applicable to autonomous spececraft. At the other end of the scale is e paper which considers launch vehicle systems from the privete sector. This mentions that, although Percheron 1 exploded during a static firing test, at least ten American companies have announced their intention to develop and operate launch vehicles with private capitel.

By producing these Guidance and Control volumes — this is the 6th to eppear — the AAS must surely heve cornered the market now in this area of space technologyl

The Neer-Earth end Interplanetery Plasme

Vol 1: General properties end fundamental theory, 299pp, £35.
Vol 2: plesme flow, plasme waves end oscillations, 259pp, £30.00.
YA.L. Al'Pert, Cambridge University Press, 1983.

These volumes deal with arees of plesma physics which have developed rapidly over the past decade. The first concerns wave processes in the near-Earth plesma (i.e. the ionosphere and magnetosphere) and in the solar wind. The second studies the effects which arise in the vicinity of bodies moving through a plasma.

Meny of the principal findings from both linear end nonlinear theories of plasma phenomena ere discussed in Vol. 1. Theoretical formulae are presented which describe the properties of the plasme in regions both near to and far from the Earth, and of the verious types of waves which occur 'here. These formulae can be used for the analysis of experimental results. Date ere also provided which characterises the structure of the plesme in these regions.

The first part of Vol. 2 presents the main experimental and theoretical results of studies of plesma flow eround bodies. Theory leeds experimentation in this aree. The second part details some of the main results obtained from numerous experiments which have involved ertificial Earth satellites and space probes. The results cover almost ell types of plesma weves observed in nature, over the entire range from below the lowest to above the highest characteristic plasma frequencies. Facts which appear likely to retain their value for future investigetions are emphasised.

Both books will prove of considerable velue to research workers and advanced students in upper atmosphere studies, es well as to plasma physicists generally. The inclusion of extensive biblioghraphies will meke it extremely useful for determining the progress made over this area.

Most of the above notes are not reviews in the ordinery sense but heve been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

spaceflight

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

NOTICES OF MEETINGS

Full details on some of the meetings listed below are to be found inside the magazine.

Film Show

SPACE BENEFITS

The use of space technology has brought countless benefits to Mankind. A few examples will be examined in a two-part film programme.

Part 1, on **11 January 1984**, 7.00–8.30 p.m. includes:

(a) Challenge and Promise
(b) Live *via* Early Bird
(c) Moonflight and Medicine
(d) The House that NASA Built
(e) Growing Concerns

Part 2, on **1 February 1984** 7.00–8.30 p.m. includes:

(a) Anatomy of Success
(b) Landsat: Satellite for All Seasons
(c) Hurricane Below
(d) David's World
(e) Space Navigation

Both parts will be screened in the Society's Conference Room, 27/29 South Lambeth Rd., London, SW8 1SZ. Members should apply in good time, enclosing a stamped addressed envelope.

Lecture

Theme: **EXPLODING STARS**

By A.T. Lawton
President of the Society

To be held in the Society's Conference Room, 27/29 South Lambeth Rd., London, SW8 1SZ on **4 April 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

One-day Symposium

Theme: **SPACE TRANSPORTATION SYSTEMS**

A one-day symposium on the above theme will be held in the Society's Conference Room on **11 April 1984**, 9.30-5.30p.m.

Offers of papers are invited. Potential authors are requested to contact the Executive Secretary at 27/29 South Lambeth Rd., London, SW8 1SZ.

Society Visit

A visit to the British Aerospace site at Stevenage in Herts, will take place on **17 April 1984**. See inside this issue for details.

History Meeting

Theme: **BRITISH ROCKETRY DURING THE SECOND WORLD WAR**

A number of contributions will be presented at a meeting on the above topic, which has been arranged by the Society's History Sub-committee. To be held in the Society's Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ on **2 May 1984**, 6.30-9.00 p.m.

Admission is by ticket only. A registration fee of £1.00 is payable, which will also cover the cost of coffee. Members should apply in good time enclosing a stamped addressed envelope.

Technical Forum

To be held in the Society's Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ on **Friday, 1 June 1984**, 6.30–9.00 p.m., and **Saturday, 2 June 1984**, 10.00 to 12 noon and 1.30–3.30 p.m.

Topic: **THE SOVIET SPACE PROGRAMME**

It is anticipated that papers will be given at the Friday evening and Saturday afternoon sessions, with some Soviet space films being shown during the Saturday morning session.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society. Members with a special interest in the Soviet space programme are invited to attend. A registration fee of £3.00 is payable. Forms are available from the Executive Secretary on request, enclosing a stamped addressed envelope.

35th IAF Congress

The 35th Congress of the International Astronautical Federation will be held in Lausanne, Switzerland on **7–13 October 1984.**

Members of the Society wishing to present papers are asked to notify Dr. L.R. Shepherd, Chairman of the BIS International Liaison Committee at Society HQ as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

Space '84

The Space '84 "weekend" will be held in Brighton on **16–18 November 1984**. See inside this issue for details.

LIBRARY

The Library will be open to members from 5.30–7.00 p.m. on the following dates:

11 Jan., 1 Feb., 4 Apr., 1984

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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CONTENTS

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PROMOTING OUR SOCIETY

We feel sure that all members will applaud and wish to support the Council in its new Society Promotion Programme which is now underway. The main ingredients being put together are:

1. Improvements to *Spaceflight*.
2. Wider Society promotion and advertising.
3. Greatly simplified membership application form.
4. More attractive Society literature.
5. More attractive meetings.
6. Strenuous efforts to hold down costs to make membership fees as reasonable as possible.

The key both to the greater expenditure which will arise and the need to absorb inflation costs lies in a bigger membership. This is why Society literature has been made much more attractive and a number of innovations introduced to appeal to newer members. We have made a number of internal changes too e.g. the introduction of word processors, considerable staff re-training and alterations to the Socity's administrative structure to take advantage of new opportunities.

There are many ways in which members can support the Society, to enhance its status and thus, indirectly, increase its attractiveness to potential members.

For our publications we need good-quality technical papers which describe new advances, ideas or concepts, together with illustrative material. The latter includes artistic work which might interest other members, e.g. astronomical or space paintings/drawings, cutaway diagrams or photographs of space-related events or personalities. Library-wise, we are meeting great difficulty in obtaining semi-historical documents, books or souvenirs of space events, so we appeal to all members with such items to consider very carefully the possibility of donating items to the Society.

The Council is determined that our Society enters its next 50 years from a position of strength. They welcome all the help which members can provide in supporting their plans for an expanding programme, and particularly with the introduction of new members. We are ready to follow up any enquiry about Society membership with introductory literature about our work and aims. So please do not miss an opportunity to let us hear about any potential new members.

COVER

Building satellites is an expensive business. Costs can be brought down by producing a standardized 'bus' and adopting it to satisfy a customer's particular requirements. Boeing Aerospace is building Mesa satellite platforms to carry small scientific or experimental satellites, using low-cost, off-the-shelf hardware. Arianespace will launch them as secondary payloads in European Ariane rockets — the Swedish Viking satellite is based on the same design.

Boeing Aerospace

MANNED PLANETARY MISSIONS?

By Dr. R.C. Parkinson

The use of manned vehicles to explore the Solar System is usually considered to be too expensive. Bob Parkinson of British Aerospace Dynamics, in a presentation to the BIS Symposium on Future Planetary Missions last October, suggests that this might not be the case.

A manned expedition leaves for Mars. © *David Hardy*

Introduction

It may seem almost an act of impertinence to address a meeting concerned with unmanned planetary exploration (and *European* planetary exploration at that) on the possibility of manned planetary missions. After all, ESA's entire science budget runs to only 106 MAU (Millions of Accounting Units) per annum, and we all know that even simple manned missions to the Moon cost many times that *per launch*. I would, however, point out that the title of this paper ends in a query. Deliberately avoiding questions of the longer term exploitation of interplanetary resources as being a separate matter, I want to ask 'Does Man-in-Space have any continuing rôle in the scientific exploration of our Solar System?

Some planetary physicists have been actively hostile to a manned space programme, seeing such "glamour" projects as absorbing the funding which would otherwise be available for scientifically rewarding robot missions. Unfortunately the historical record speaks against them. Let us look at NASA's total budget and spending on unmanned planetary sciences since its inception, expressed in constant 1982 dollars. I do not have planetary science data for 1969 and 1970, but the evidence is that unmanned planetary science spending was high in the heady days of the Apollo programme, achieved a temporary high in 1972/3 with the Voyager and Viking programmes, and then slumped along with the rest of the space programme. The real concern is that currently, with declining Shuttle development spending and the absence of a competitive manned programme, the US planetary sciences community is still failing to get funding on "new starts."

The European position is simpler. ESA has a fairly constant 100 MAU/yr (1982) to spend on space science in general, and planetary missions complete with space astronomy and geophysics on what is hoped to be a "scientific merit" basis.

I feel that the truth is that the finances for unmanned planetary exploration have little to do with the finances for "Man-in-Space," but both have a lot to do with how attractive the public and our political paymasters see either enterprise. If there is popular approval for space activities then both manned and unmanned activities will flourish. Otherwise both will wither away.

There is actually a divergence between the planetary physicist's view of space exploration and that of the general public. The physicist's aim is to do interesting physics, to get as many and as varied measurements as possible, to place diverse and sensitive instruments at precise locations. The public's interest is "to boldly go where no man has gone before," to see new worlds before us and discover new horizons. To the public the most important instrument on any spacecraft, sometimes the *only* imporant instrument, is the camera.

The dream, after all, is for *us* to go out into the Universe and set foot on strange new worlds.

Some of this is apparent if you list the unmanned planetary exploration programme seen by the physicists, as in Table 1, and compare it with a manned view of the same thing (Table 2). There are 29 serious proposals on the unmanned side before we reach the "etc," and while they are perhaps more wide ranging than the manned view, nobody really believes that we will achieve 29 missions in, say, the next quarter century.

I am not suggesting that we should immediately abandon an unmanned planetary programme in favour of a manned one. However, the mere complexity of a manned mission would make the information capture of such a

TABLE 1: Unmanned Planetary Exploration

Jupiter Orbiter/Probe (Galileo)	Saturn fly-by/probe
Cometary fly-by (Giotto)	Uranus fly-by probe
Solar polar (ISPM)	Neptune fly-by/probe
Venus radar mapper	Mercury orbiter/hard lander
Mars geoscience/climatology orbiter	Mars sample return
Comet rendezvous/asteroid fly-by	Comet sample return
Titan probe/radar mapper	Jupiter orbiter satellite tour/lander
Mars aeronomy orbiter	Venus lander/balloon
Venus atmospheric probe	Asteroid sample return
Mars surface probe	Sunprobe
Lunar geoscience orbiter	Europe sample return
Comet atomized-sample return	Uranus orbiter
Multiple mainbelt asteroid orbiter/fly-by	Jupiter/Pluto fly-by
Earth approaching asteroid rendezvous	Neptune orbiter
Saturn orbiter	etc.

probe like Viking. And, were the funding and hardware available today, we could probably mount a manned mission to Mars without further unmanned missions. There are four separate Mars missions listed in Table 1, and a side visit to one of the Martian moons would probably be of equivalent value to any asteroid rendezvous/sample return.

We are all also acutely aware of the growing difficulties of planetary exploration as the "easy" missions are used up. Although Mars Surface Rovers and Mars Sample Return missions remain a target of primary importance since Viking, there seems less and less possibility of funding a robot mission of such complexity in the foreseeable future. Initially such missions could have built on available Viking hardware, but as time goes by it will probably be necessary to "start from scratch" if such a mission is proposed, and this will also add to the total cost.

The Space Station

Manned space activities in the 1990's may actually serve to reduce some costs. One of the important justifications for the proposed manned Space Station is as a transportation node to geosynchronous orbit. Spacecraft would be launched into low Earth orbit independently of any upper stage, and then mated to a high-performance, re-usable "Orbit Transfer Vehicle" for carriage to high orbit. This is the old Space Tug concept of the 1970's. Various operational modes have been proposed, the preferred probably being an aerobraking recovery because this would allow payload retrieval from geosynchronous orbit. While current perigee stages deliver for a total cost of about $30 million/tonne in geosynchronous orbit, and

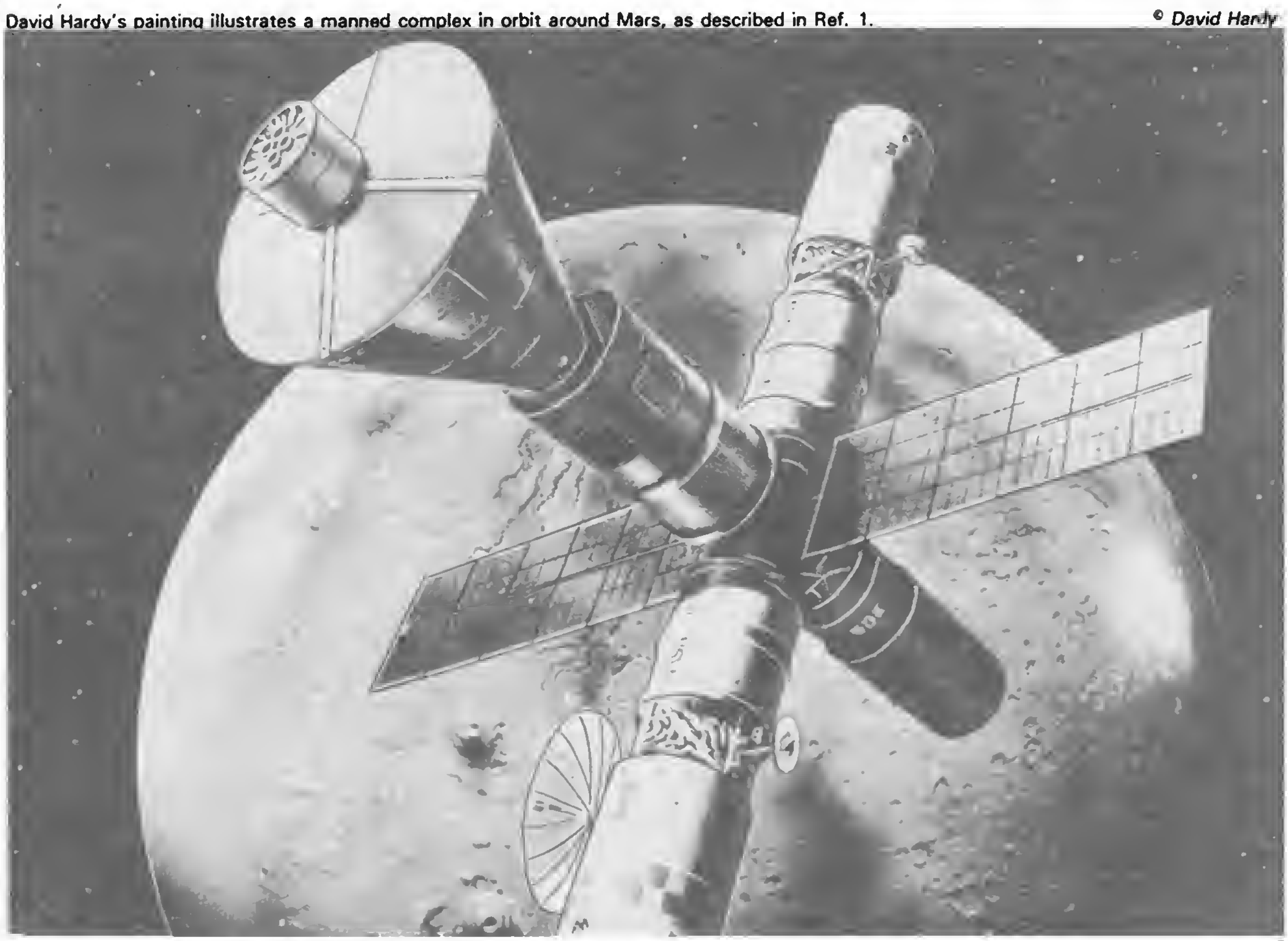
TABLE 2. Manned Planetary Exploration
Explore the Moon
Explore Mars
Mission to an Asteroid
Explore Jupiter System
Explore Mercury
etc.

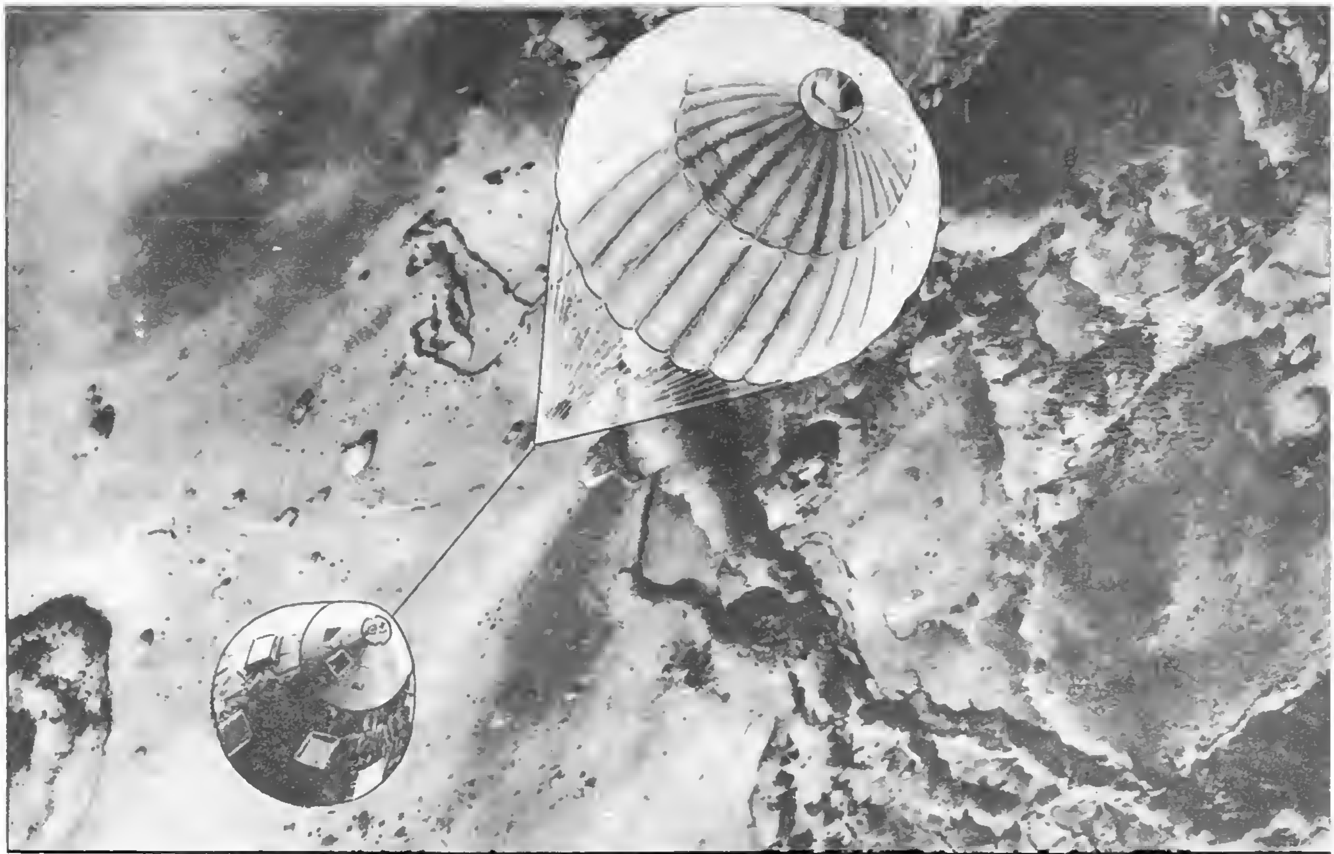
even the Shuttle-based Centaur is expected to cost about $24 million/tonne, the OTV is expected to reduce overall launch costs to about $11 million/tonne. A capability to geosynchronous orbit is essentially the same as a capability to Earth escape.

The OTV will probably be big. Figures of 10 tonnes payload to GEO have been quoted. In the days of the Space Tug studies British Aerospace proposed to use life-expired Tugs to launch planetary vehicles. It is not clear that the OTV will be operated in this way, but the high payload capability (a derivative of the manned operations background) can certainly be used to give added capability or reduced cost to the payload, perhaps by using off-the-shelf and far from optimum components. Captain Cooke used second hand commercial ships for his epic explorations of the eighteenth century, and this could be repeated in the 21st.

The manned Space Station has also been seen as

David Hardy's painting illustrates a manned complex in orbit around Mars, as described in Ref. 1. © David Hardy





An artist's concept of a Mars lander during descent to the Martian surface. This is an illustration from "An Expedition to Mars" by Bob Staehle of the World Space Foundation in the January 1982 issue of *Spaceflight*. Artwork by Paul Hudson.

an important enabling step towards developing surface sample return missions, both in providing a platform for the assembly and check-out of complex, multi-component spacecraft and also in providing a suitable recovery point.

However, my feeling is that in the long run manned missions are more effective, more attractive and ultimately cheaper than multitudes of unmanned missions. Apollo told us a great deal more about the Moon that the sample returns and Lunokhod surface rover adopted by the Soviet Luna programme, and indeed it can·be argued that without Apollo the US planetary programme would have been far les effective. My own 1981 study [1] of a manned mission to Mars at the end of this century, drawing on Space Station hardware, suggested that this did not have to cost more than 10 times that of individual Viking spacecraft. Such a mission might have a similar reinvigorating effect on other planetary missions.

The Mars mision study revealed another important facet, however. While the primary event was a manned landing on Mars, with a side visit to Phobos, the expedition as designed carried three robot surface sample landers, six subsurface penetrators, an orbital satellite and two Venus sounder probes. The design and operation of these secondary spacecraft were all facilitated by the presence of a large mother ship and human intervention nearby, but nevertheless robot missions out-numbered humans by 2.4 to 1.

This man-machine symbiosis is likely to develop as time passes. The Solar System in some respects is still less hospitable than we once thought. No human foot is likely to set foot on Venus in the foreseeable future, and the manned exploration of the Jupiter system will be inhibited until we develop some means of dealing with the radiation environment. Furthermore, long duration manned missions (>3 years) will have to tackle the problems of extended duration weightlessness, crew confinement and protection from solar flares and galactic background radiation. These problems may all be soluble, but in the short term we shall need machines to go where men cannot. At the same time, having men on hand, particularly as teleoperator experience grows, may provide an essential executive function in guiding clusters of robots through a multiple objective mission.

I can imagine a 21st century expedition to the Jupiter system, perhaps using large nuclear-electric carriers, in which the manned vehicles park safely in the outer system while robot vehicles probe the multitudes of moons. There is readily accessible ice on the Galilean moons which could be electrolysed for propellant, and tugs and sampling robots could visit one destination after another, following a mission plan continuously updated by the human controllers. Indeed, the manned element might serve as an initial 'receiving laboratory' — actively doing science rather than simply carrying out instructions. Such a mission would provide all the excitement of manned exploration whily carrying out a mission of immense usefulness far beyond the ability of the men alone.

Ultimately, the question of manned planetary exploration is not one of cost effectiveness, however, but one of values. We — and by we I mean the human race as a whole, not just the scientific community — spend money on space because we value it. The amount we spend on space activities is the amount we value the results. Interestingly, the only argument against manned space programmes appears to be that 'it is too espensive,' and even that will change with time. In the meantime, simply to leave the role of man-in-space to the points at which his presence is commercially justified is to ignore the very real human dimension to the exploration of the worlds about us.

REFERENCE

1. R.C. Parkinson "A Manned Mars Mission for 1995," *JBIS*, **34**, p.411 (1981).

BE A PART OF MAN'S JOURNEY INTO THE COSMOS

SPACE '84

16-18 November 1984

SPACE — THE FUTURE OF MANKIND

The success of Space '82 has encouraged us to organise Space '84 and provide another opportunity for our members and guests to become involved in space. Once more we will gather together a host of space experts, scientists and space popularisers to provide delegates with a unique view of what is going on in space today and how it will affect "The Future of Mankind." Space '82 saw astronaut Deke Slayton, former NASA Administrator Tom Paine, astronomer Patrick Moore and many others... Space '84 will be no less star-studded.

The theme will be "Space — The Future of Mankind," with individual sessions on:

New Frontiers
Discovering the Universe
The Ways and Means
Foothold in Space
Advancing Frontiers
The Future of Mankind
Workshop (2 sessions)

Fuller details will be published in future issues of *Spaceflight* to keep all readers fully informed as our plans develop.

The Brighton Centre on the south coast will play host to the Society on **16-18 November 1984,** with its excellent facilities at our disposal.

To keep the friendly, intimate atmosphere of Space '82, the number of places available will be held down to 400. Experience shows that these will soon be snapped up, so early application is essential. Simply fill out the form below and send it to The Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

Yes, please send me a Registration Form and further details on Space '84.

Name: ....

Address: ....

....

....

SPACE '84

MILESTONES

October 1983

16 The Soviet Venera 15 Venus orbiter begins sending back radar images of the planet's northern surface with a resolution of about 2 km. Venera 16 begins operations on the 20th. The pictures show craters, mountains and basalt "seas."

20 The Progress 18 tanker craft is launched to refuel the Salyut 7 space station. It docks on the 22nd. Western observers believe that a serious leak on 9 Sept lost most of Salyut's oxidizer. The new supply means that Salyut can again begin experiments that require precise orientation. The tanker is detached on the 13th; it burns up on the 16th.

21 The US ISEE 3 satellite makes its second pass by the Moon (the first was on 21st Sept); a third swing-by on 22nd December within 120 km of the surface will send it towards a 5 Sept 1985 meeting with Comet Giacobini-Zinner.

24 Shuttle STS-9 is being disassembled in the VAB to replace the right-hand booster bottom segment with one intended for STS-12. Return to the launch pad is due on 10 Nov for a 28 Nov launch. The delay to November will cost ESA at least $300,000. The External Tank and boosters are mated again on the 27th. The change in the mission dates means that some of the experiments will be reflown to acquire full data.

31 *Aviation Week* notes that a Soviet Saturn 5-class booster is on the pad at Tyuratam and approaching launch. US civil and military planners are considering a new large unmanned launcher to supplement the Shuttle.

November 1983

1 Squadron Leader Rakesh Sharma of the Indian Air Force will fly an 8-day Soyuz mission in April; Wing Cdr. Ravish Malhorta is his backup, it is announced. (See 'Space Report' for a picture).

1 Salyut 7 cosmonauts Alexandrov and Lyakhov make a space walk to install a solar panel on the exterior of the space station. A second panel is installed on the 3rd.

7 Cosmonaut Aleksei Yeliseyev says that the present Salyut 7 crew will return to Earth at the end of the month, it is reported (they land on the 23rd 160 km E. of Dzhezkazgan). The next crew, for a long duration mission, will be launched early next year. He also noted that, although several women are in training, no missions are yet planned using them.

9 Shuttle Orbiter *Discovery* is delivered to the Kennedy Space Center. It will fly the STS–14 mission, scheduled for launch on 4 June.

14 The Soviets are planning a 1986 rendezvous mission with the Martian moon Phobos, it is reported.

21 STS–12 is officially cancelled, it is reported. The whole crew will now replace the STS–14 team on Orbiter *Discovery*. Other crew changes will probably result.

22 The IRAS satellite runs out of liquid helium, bringing the survey mission to an end.

28 STS-9/Spacelab 1 is launched at 16.00 GMT.

DO YOU KNOW?

The picture below shows a piece of Society history. Can you name the two men involved and the event.?

Answer: Society President W.R. Maxwell (right) is shown presenting an Apollo Lunar Module trophy at the Royal Society in 1970 to NASA Administrator Tom Paine to mark the first manned lunar landing.

DO YOU REMEMBER?

25 Years Ago...
6 February 1959. The formal contract for the McDonnell Aircraft Company to supply 12 Project Mercury capsules is signed.

20 Years Ago...
30 January 1964. The first Block III Ranger (Ranger 7) spacecraft is launched. It was planned that Ranger 6 would take television pictures of the lunar surface during lunar approach but high voltage arcing during launch prevented this.

15 Years ago...
16 January 1969. Soyuz 5 cosmonauts Yeliseyev and Khrunov perform a 1 hour EVA, transferring from Soyuz 5 to the docked Soyuz 4. Actual time outside was 37 minutes.

10 Years Ago...
5 February 1974. Mariner 10 flies within 5,768 km of the planet Venus en-route to the innermost planet, Mercury.
12 February 1974. The Soviet Mars 5 spacecraft enters a 1,760-32,500 km orbit around the planet Mars.

5 Years Ago...
25 January 1979. NASA announces the names of the four Space Shuttles. They are *Columbia, Challenger, Discovery and Atlantis*.

K.T. WILSON

BIS Memories

Sir, I was fascinated to read Frank Winter's description of the "Formative Years of the BIS," in the November issue, and particularly pleased to see the column by P.E. Cleator, who was directly responsible for my membership, although he is probably unaware of the fact, or has forgotten if he ever knew. During a brief interlude at RAF Hemswell in 1943 I read with enthusiasm his *Rockets Through Space*, a copy of which was in the station library. I wrote to the address given in the book but did not really expect a reply at that time. In any case I was rather busy soon after that with a tour on Lancasters.

However, in 1947, out of the blue came an invitation to join the BIS, and I eagerly accepted. At that time my family laughed to scorn any idea of space travel (as did a certain highly appointed astronomer). My own father was once heard to say "They'll never conquer the air." But the most amusing remark for me was the discovery of the following, not many years ago, in a tattered copy of *The Children's Encyclopedia* in the school library of which I was in charge: "Some people think it may one day be possible to travel to the Moon. It is very dangerous in science to say what may or may not happen, but in this case we think we are quite safe in saying that man will never reach the Moon!".

Anyway, thanks to P.E. Cleator and the BIS for 36 years of membership.

JOHN ALLISON
Warley, W. Midlands

Fifty Years On

Sir, As a layman, may I join in offering congratulations to the British Interplanetary Society on its Golden Jubilee.

In a very tenuous sense, I too was in at the birth of the Society. I hope I am not giving too much away when I say that, in 1933, Len Carter and I, at the age of 11 or 12, were receiving our statutory ration of education at a Council School little more than a mile away from the Society's present headquarters. Even in those days, Len was apt to get starry-eyed when it came to things extra-terrestial. In the following year, when *Scoops* appeared, he must have been the first reader; I distinctly remember him drawing my attention to a printed item which told of the foundation of the Society.

Although my leanings were towards music, we became very close friends. Since he did most of the talking and, in any case, was pretty near tone-deaf, exchange of information on our respective interests tended to be somewhat one-sided.

Due to the elementary nature of our school-leaving qualifications, neither of us at the outset were able to make much headway in our natural vocations. The War [the Second, not the First! *–Ed.*] separated us but later we were able to resume our friendship to find two remarkable parallels. We were both working as accountants and secretaries having achieved professional status in the only way open to us, by the light of the proverbial midnight oil at the end of the working day. Then again, we had both pursued with undiminished intensity our boyish enthusiasms.

I had a second occupation as a semi-professional musician and, in later years, as a musical journalist and author, at the same time as working in commerce. Len eventually was able to combine his two careers on becoming the Executive Secretary of the British Interplanetary Society. To so many of us he *is* the Society.

Fate and fortune took me into the domestic glassware industry — and here we come to a big difference. Whilst the work of the Society can be only of long-term, indirect benefit to my Company, I notice that when Fellows and Associates meet to discuss matters grave and profound, they are not above taking a little liquid refreshment to stimulate the mind and inspire the tongue. Although not being able to supply the beverages, at least I can play a humble part in the advancement of science by providing elegant and pleasing receptacles for the partaking.

Although perforce our education was pretty basic, it was none the less sound and a solid foundation on which to build. Some years ago we were fortunate in tracing two of our teachers from 50 years ago. The teacher-pupil relationship is now but a memory. We are all men of mature years and the very best of friends. It was a unique privilege and pleasure of have E.E. ('Ozzy') Osmon and G.E. ('Tommy') Thomas as our guests at the Anniversary Dinner as but a slight gesture of appreciation of the debt we owe to them and their colleagues of The Paragon School in those far-off days.

I am proud to be a Member of the British Interplanetary Society and to follow as best I can the staggering course of development in space exploration.

My interest stems directly from an enthusiastic schoolboy in the dingy back streets of Walworth half-a-century ago.

WALLY HORWOOD
Director & Group Secretary
Western Glass Works (Holdings) Ltd.
Basingstoke, Hampshire

Mr. Horwood very generously presented the Society with 150 beautiful wine glasses which were used for the two Anniversary dinners.

Space Exploration of the Future

Sir, I refer to the NASA schedule for space exploration published in the June 1983 issue of *Spaceflight*. To decide whether the proposals are realistic I believe that several factors ought to be taken into account. These are:

1. The technical feasibility of the proposals;
2. The health of the US economy;
3. The state of the relationship between the super-powers.

I do not doubt that the plan is technically feasible. The proposals clearly require a significant long term commitment with little prospect of any sizable return on the investment for several decades.

At present it is apparent that significant surplus resources (over and above these needed to invest in traditional industries and increase living standards) do not exist, at least in the Western economies. After years of slow economic growth, combined with a marked increase in military expenditures, the US is faced with a 1983 budget deficit of $200,000 million. In the political battle to reduce the deficit the NASA budget is a relatively easy target.

However, more important than the technical and finan-

superpowers and as a result of that the political mood in America. The US space effort has been dominated by military and political concerns since the late 1950's. President Reagans 'Star Wars' speech in March 1983 indicates that this influence will continue. Whilst space stations in low Earth orbit and geostationary orbit clearly have military uses, flights to the Moon and Mars do not, so any commitment to such landings in the forseeable future will have to be for purely political reasons.

DAVID ROBERTS
Stockport

Shuttle Night Launch

Sir, I thought that *Spaceflight* readers would be interested in a first-hand account of the first Shuttle night launch. Here are my impressions.

"Weather best ever for Shuttle's flashy launch." This was the headline in the local Florida newspaper on the eve of the first planned night launch on 30 August 1983. NASA Launch Director Al O'Hara probably wished he had never uttered the ironic words when a violent storm moved over Kennedy Space Center three hours before the scheduled 2:15 am (local time) liftoff.

Upon arrival in the Cape Canaveral area a week before the flight, I learned that *Challenger* faced a return to the Vertical Assembly Building due to an approaching hurricane. Fortunately, the forecast wind velocity was below the level that the exposed Shuttle could withstand on the launch pad, and the move was never seriously considered. Any threat from Hurrican Barry evaporated when the storm fizzled out before crossing the Florida coastline just south of the Cape.

The next few days were spent enjoying general press tours (including a brief visit to the launch control centre firing room) in the company of a colleague from the Netherlands. The agenda for the last full day before launch included the Service Structure rollback, and astronaut departure from the crew qaurters.

Challenger looked magnificent as the Rotating Service Structure was retracted at mid-day. The massive size was evident through binoculars, and the pattern of the tiles was easily discernable. After sundown, *Challenger* was breathtakingly beautiful in the dazzling illumination of the zenon searchlights.

After the return to the press site, a thunderstorm unexpectedly moved into the area, triggering continuous lightning displays. The ominous activity intensified during the bus ride out to the Operations and Checkout building to see the astronauts emerge from their quarters. Waiting for the crew to appear, the heavens opened up with a tremendous downpour. We were all thoroughly drenched by the time the astronauts stepped out of exit C-7 for the short walk to the transfer vehicle (a holiday motor home!).

With liftoff about three hours away, my spirits were more than slightly dampened by the heavy rainfall. The rain slackened to a light shower by 12:30 am, and finally stopped about 90 minutes later. Prospects for liftoff were not good, and it came as no surprise that the launch director elected not to resume the count at the T-9 minute mark after the end of the upcoming final 20 minute hold.

The launch directorate was willing to hold as long as window. Astronaut Bob Crippen, flying the Shuttle Training Aircraft, relayed an encouraging weather report at about 2:15 am. The two cloud decks in the vicinity of the pad were without moisture, he reported, and visibility was good. It did not take long for the new launch commentator, 27 year old Mark Hess (replacing Hugh Harris, now chief of public affairs at KSC) to announce that the count would be picked up at the T-9 minute point at 2:23 am, resulting in a launch delay of 17 minutes.

A tension-filled nine minutes followed the sudden announcement of a 'go' for launch, punctuated with nervous pacing and frequent camera checks. The magic moment arrived and the lights of Pad 39A were overwhelmed as the Shuttle main engines flared into life. Ghostly orange-hued steam clouds boiled outward, signalling booster ignition. The fire gadually lit up the entire area with an odd, muted peach-coloured light when *Challenger* lifted off at 2:32:00.082 am EDT.

As the vehicle magestically completed the roll and pitch programme, the lengthening pillar of flame twisted like a giant scimitar poised over the launch pad. At this point (at about T+15 seconds) the shock wave reached the press site. The crackling roar built to a staggering crescendo that approached the ear's threshold of pain. Nothing demonstrates the stupendous power of the Shuttle as well as the wall of sound that inundates the observer shortly after the Shuttle clears the tower.

Excessive moisture in the air, an aftermath of the heavy rainfall, created a fuzzy orange halo around the rocket motors and a long plume of smoke trailed the rising Shuttle. For a moment before SRB separation it seemed that a second Moon had appeared in the sky adjacent to our natural satellite, which was also enveloped in a hazy orange glow from the overcast. By the time the boosters separated, the Shuttle was no longer visible except as a faintly glowing patch in the southeast sky.

The entire glorious spectacle lasted only two minutes. Night was briefly turned into day by the unearthly light of the rockets, creating an unforgettable pastel yellow and blue landscape. The excitement of the moment quickly died away after *Challenger* disappeared from sight. Eight minutes after liftoff the main engines were shut down precisely on time, and after two flawless OMS burns the spacecraft attained the planned 290 km orbit.

The STS-8 crew was no less impressed with the night launch than those left behind. Commander Truly compared the liftoff to "driving through a fog bank that had an internal orange light source." Dale Gardner nearly blinded himself during ascent as he viewed the "ball of flames" visible through the cockpit and overhead windows. Most surprising to the crew was the eruption of flame that occurred when the External Tank separated. It appeared that the fire "was never going to stop," according to Mission Specialist Gardner. The crew was astonished at the brightness and intensity of the light from the Shuttle rocket motors.

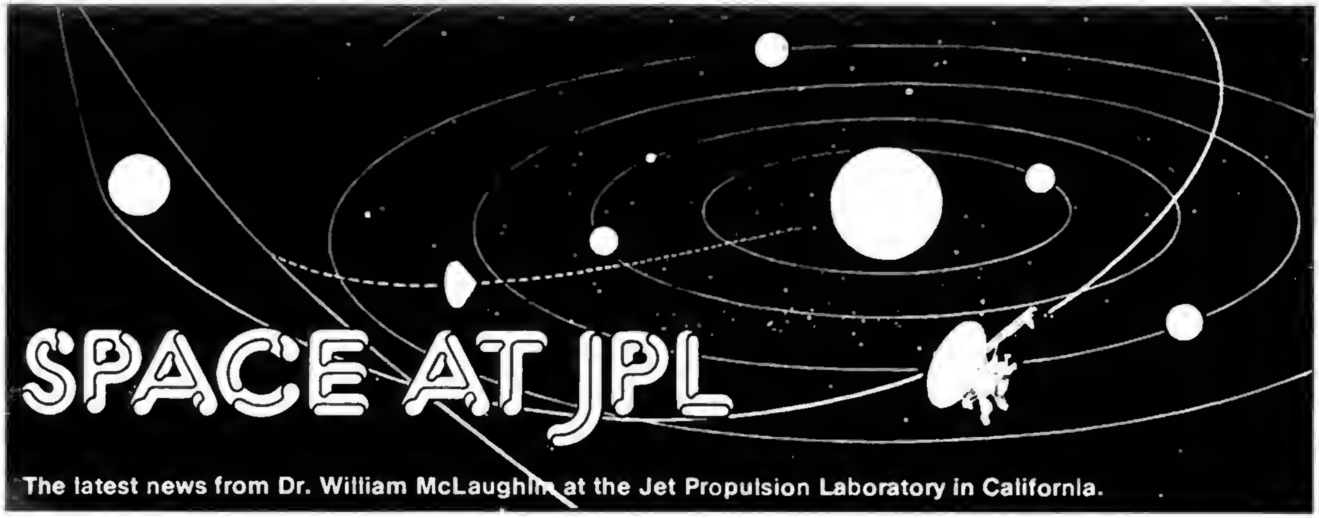
JOEL POWELL
Calgary, Canada

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

SNIPPET

Sir, I would like to pass on my thanks on behalf of the South Lincolnshire Astronomical & Geophysical Society for the BIS publicity material which you sent so promptly. It provided significant extra interest at our recent exhibition and we passed on membership forms etc to as many people as possible. The remainder I will keep to hand out to anyone who expresses an interest in the subject!

CLIVE SIMPSON Spalding, Lincs



VOYAGER IN CRUISE

Launched in 1977, the two Voyager spacecraft have each encountered Jupiter and Saturn: Voyager 1 making closest approaches in March 1979 (Jupiter) and November 1980 (Saturn) with the corresponding encounters for Voyager 2 occurring in July 1979 and August 1981. Voyager 1 will proceed out of the Solar System without any further planetary encounters, but Voyager 2 is scheduled to pass through the Uranian system in January 1986 and the Neptunian system in August 1989. This upcoming exploration of the two distant gas giants has been described by S.J. Kerridge in the August 1983 issue of *JBIS*.

One might think that during the cruise phase from Saturn to Uranus the level of activity would be low, but such is not the case. Both spacecraft are gathering data about the interplanetary medium by using the fields and particles instruments which they carry, and observations of astrophysical and planetary objects are being made with ultraviolet spectrometer and the other pointing instruments (see, for example, *The Astrophysical Journal* **257**, 15 June 1982, pp.656-671). In addition, engineering tests and modifications are being made onboard the spacecraft and on the ground in order to prepare for the encounter with Uranus.

One engineering task of high priority is to understand the causes of the problem that arose with the Voyager 2 scan platform shortly after the Saturn encounter in 1981. The scan platform houses five of Voyager's instruments, includings its television system. It can be moved in order to point these instruments at selected targets: planet, rings and satellites. Clearly, it is a key piece of equipment. Its mechanism seized while moving in the azimuth direction just after closest approach to Saturn, resulting in some loss of data. No problems have occurred in the elevation direction.

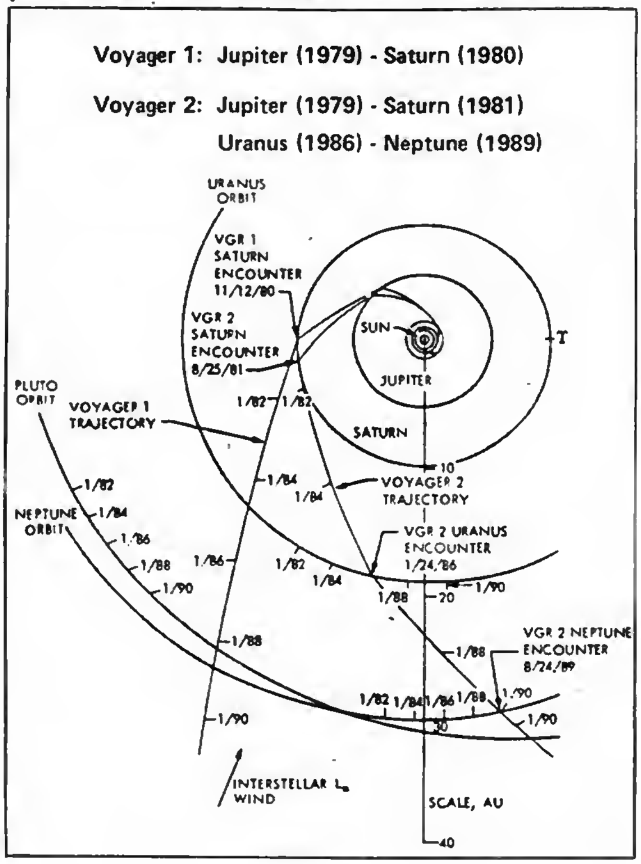
Several near duplicates of the "azimuth actuator" mechanism have been built and are undergoing testing at JPL to understand the nature of their degraded capacity through wear. Also, a flight spare of this device exists and is being tested. A model of the failure mechanism of the azimuth actuator is emerging as a result of this testing, and confidence is growing that, barring an unexpected failure in the next two years, the scan platform will function satisfactorily at Uranus if its use is carefully regulated. An onboard testing procedure ("torque-margin test") has been devised which yields some information concerning how close the scan platform is to seizing up at any time and, thus, corrective and protective measures can be undertaken if so indicated.

In parallel with investigation of the scan platform's health, an alternative method of pointing the Voyager 2 instruments has been devised and is under continuing examination. This method substitutes motion of the spacecraft about its roll axis for azimuth motion of the scan platform. It might be compared to someone with a stiff neck turning his head ("scan platform") by moving the whole body rather than using the neck itself.

The Voyager 1 spacecraft, in addition to conducting its programme of scientific observations, is of value as a test bed for certain engineering procedures before they are implemented on the more precious resource, Voyager 2.

The Voyager Uranus/Interstellar Mission (VUIM) is managed by the Jet Propulsion Laboratory for NASA's Office of Space Science and Applications.

The trajectories of the two Voyager spacecraft are shown in this plan view of the outer Solar System. Voyager 2 will encounter Uranus in 1986 and Neptune in 1989. Voyager 1 has no further planetary flybys.



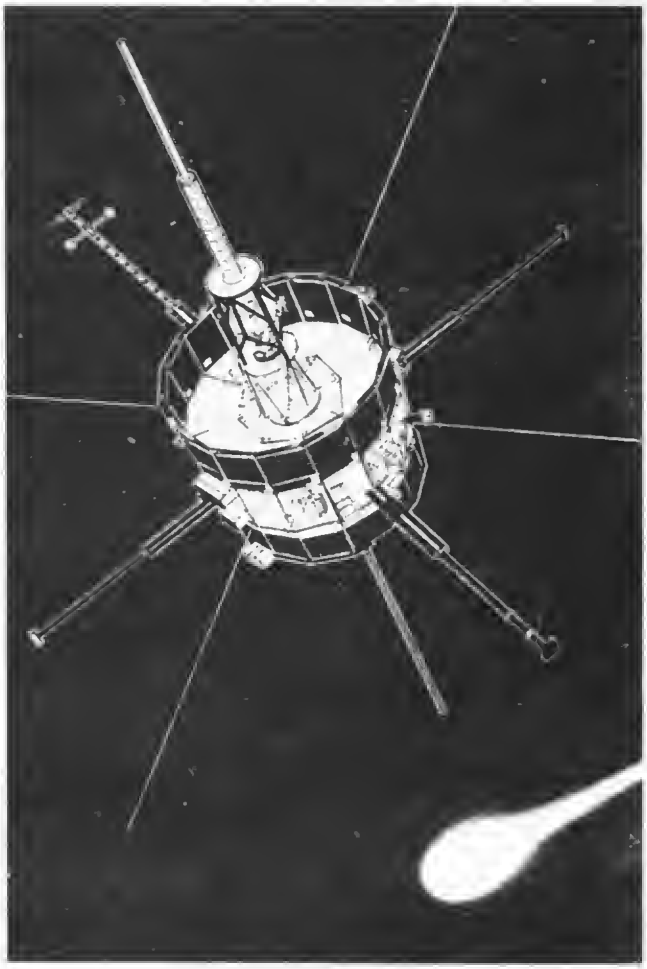
ADVANCED MISSIONS TO COMETS

This month's advanced-concept review touches upon the class of comet missions beyond the 1986 flyby of Halley (Giotto, Planet-A and VEGA spacecraft) and the 1985 probe into Giacobini-Zinner (ISEE-3 spacecraft). None has been funded yet, but the exploration of comets has been placed high on the priority list of the Solar System Exploration Committee (SSEC) of NASA. In its 1983 report "Planetary Exploration through year 2000: A Core Program," the SSEC has proposed a strategy of exploration which includes two types of missions: rendezvous and atomised sample return.

The vehicle of choice for the comet-rendezvous mission is the Mariner Mark II (MMII) spacecraft, now under conceptual development at JPL. If produced, this class of spacecraft would be used for deep-space missions to the outer planets as well as comet rendezvous. It has been demonstrated that comet rendezvous can be accomplished by means of chemical propulsion systems such as those of MMII; many earlier rendezvous studies have assumed the existence of continuous-thrusting, solar-electric propulsion systems. However, this type of engine lies in the domain of advanced technology and might be expected to carry a higher price tag than classical chemical propulsion, at least for the near-term future. The MMII mission would be launched in the early 1990's by a Shuttle/Centaur combination with rendezvous taking place in the middle of the decade, after a series of carefully designed manoeuvres had placed the spacecraft on a matching trajectory with the comet. In order to minimise energy demands on the spacecraft's propulsion system, a comet of low inclination with respect to the ecliptic would be targeted. Periodic comets Honda-Mrkos-Pajdusakova and Kopff have been discussed as candidates for rendezvous. An ideal mission would be to maintain rendezvous and data-taking for an entire period of the comet so as to study its total cycle of development as it approaches and recedes from the Sun along its elliptical orbit. An attractive feature of a comet rendezvous mission is that, in most cases, it is possible to include a spacecraft close-flyby of an asteroid on the way to the rendezvous, thus achieving observation of a representative of a member of the second class of small bodies in the Solar System, another SSEC objective.

In addition to exploration of a comet with the rendezvous technique, it would be highly desirable to obtain material from the comet and return it to Earth for analysis in the laboratory. The SSEC has proposed taking this sample by using a spacecraft on a fast flyby close to the cometary nucleus. Particles from the coma surrounding the nucleus would impact and penetrate a thin diaphragm at velocities of 10 to 70 km/sec. After "atomisation," the vapour from these particles would condense on the interior walls of the collector for later analysis on Earth. Division of the collector into small collecting cells would facilitate chemical analysis of individual cometary particles that had been vaporised. In order to obtain scientific results complemetary to those of the comet rendezvous mission, it would be preferable to investigate the same comet for both missions. The sample would be returned to Earth *via* a small atmospheric-entry capsule. The spacecraft to be employed for atomised sample return could be drawn from either the MMII class or the Planetary Observer class, depending upon mission requirements. The latter are essentially converted Earth satellites and are being proposed for missions in the inner Solar System such as the Mars Geochemical/Climatological Orbiter (see "Space at JPL" in the December 1983 issue).

It is interesting to note that comet samples have already been obtaind by use of a high-flying NASA U-2 aircraft.



The 1985 probing of Comet Giacobini-Zinner by ISEE-3 will help to establish the background for a future cometary rendezvous. The satellite flew to within 100 km of the Moon on 23 December last as part of the manoeuvres to reach the region of the comet in 1985.
NASA

Above most of the atmosphere at 20 km, the aircraft has collected numerous dust particles which are thought to be of cometary origin; an estimated 10^7 kg of cometary dust settles to Earth each year.

Going beyond the immediate SSEC programme for this century, Dr. David Morrison of the University of Hawaii, and SSEC chairman for 1983, has described a comet sample-return mission wherein a core sample of several centimetres in diameter and a metre long would be taken directly from a cometary nucleus and returned to Earth. Hermetically sealed and maintained at its original temperature, this sample would provide an enormous amount of information concerning some of the Solar System's most primitive material. It is also possible to foresee the development of monitoring stations, analogous to the Viking Landers on Mars, implanted on the surface of the nucleus and taking temperature and checmical measurements for one or more cometary periods.

IRAS PRESS CONFERENCE

On 9 November 1983 a press conference was held in Washington, DC in order to present the principal scientific results obtained to date from the Infrared Astronomical Satellite (IRAS). At the conference were representatives from each of the three partners in this international effort: the US, the Netherlands and the UK. A brief synopsis of the main discoveries is given below; for a more complete analysis, the March 1984 issue of the *Astrophysical Journal* should be consulted.

Galaxies

IRAS should observe about 10 to 20 thousand galaxies, obtaining measurements of their output of infrared energy. Some of the galaxies are emitting 50 times more energy in the infrared than in the visible region. The infrared output is due to the ongoing process of star formation and to emission from dusty regions in and about the galaxies.

Milky Way Galaxy

Infrared radiation passes more easily than visible light through clouds of dust, hence the centre of our Galaxy, normally shrouded by dust, is more easily studied in the infrared. Views of this region synthesised from the IRAS observations "give us a new perspective on the complexity and beauty of our Galaxy" according to Science Team member, Dr. Michael Hauser.

Star Formation

About one Sun-like star per year is being formed within our Galaxy. The IRAS telescope is particularly well-suited to studying regions of stellar formation; in Barnard 5, a cloud of molecular hydrogen about 1000 light years distance in the constellation of Perseus, as many as four young stars have been observed.

Infrared Cirrus Clouds

A new phenomenon, termed "infrared cirrus clouds" by the IRAS astronomers, consists of material irregularly spread across the sky at great distances from the Sun. Measurements show that it must be more than 1000 AU from us (one Astronomical Unit is the distance from Earth to Sun). The cirrus probably resides in interstellar space (or it might be a distant part of our Solar System, associated with the Oort cloud of comets). It is thought that the cirrus is principally composed of graphite dust.

In addition to the irregular cirrus formations, a more uniform component of infrared radiation has been observed over all of the sky.

Vega System

The discovery by IRAS of millimetre-sized, or greater, particles circling the first-magnitude star Vega has already excited great attention in the press (see "Space at JPL" in the December issue). With the IRAS telescope, it is not possible to determine whether there are planets in the Vega system.

Comets

Five comets have been discovered by IRAS. In addition, an unusual object, designated minor planet 1983 TB, has been found to orbit very close to the orbit of the Geminid meteor stream. This object, only a few kilometres in diameter, may be the parent body of the Geminids and, as such, could be the remains of a comet nucleus. It passes more closely to the Sun than any other known object, including the planet Mercury.

Observations of the previously-known comet Tempel 2 have revealed a long trail of cometary debris associated with it.

Dust Rings in the Solar System

Three previously unsuspected rings of dust have been discovered lying in the region of the asteroid belt between

An artist's concept of the ring of material around the star Vega. The plane of the Milky Way is to the right. As shown here, the ring is thin enough to allow stars to shine through. *NASA*

Mars and Jupiter. These rings may result from numerous collisions between asteroids over the ages, or they could represent the results of a single, more catastrophic collision between comets or asteroids.

Spectroscopy

Over 30,000 stellar spectra have been obtained by IRAS. Only a few hundrerd have been analysed to date, but interesting features such as neon lines have already been detected.

Orion Features

An exciting composite of dust and gas clouds in the Orion region has been assembled. Some of the features correlate with known visible structures such as star formation regions in the "sword" of Orion, but others are entirely new, including a giant shell of gas which appears as a ring-like object in the synthesised picture of Orion.

Unidentified Objects

About 100 objects that do not correlate with visible or radio objects have been detected by IRAS. They appear to fall into three classes: (1) small groups or clusters of objects probably associated with star formation, (2) more intense regions seemingly associated with the cirrus phenomenon, and (3) objects not associated with any other phenomena. This latter class could be distant galaxies which are very bright in the infrared.

The IRAS catalogue of about 250,000 sources resulting from processing of its all-sky survey, will be published in the summer of 1984 and should serve generations of astronomers as a guide to further research. The next major follow-up to IRAS planned by NASA is the Shuttle Infrared Telescope Facility (SIRTF), whose operation is anticipated early in the next decade.

The US portion of IRAS is managed by the Jet Propulsion Laboratory for NASA's Office of Space Science and Applications.

ARCHIVING NASA's DATA

Entropy is one measure of a system's disorder, and by the second law of thermodynamics entropy generally increases with time. Pity the poor archivist and librarian faced with the inexorable operation of this principle with respect to their collection of data.

After 25 years of space flight, NASA has accumulated a vast set of observations from Earth satellites and interplanetary missions. Some of these observations have congealed into concepts and are safe from decay, e.g., "the Solar System is laced with active magnetic fields." Other data have been preserved in the conventional media of books, papers and films. Video discs (see the November 1983 "Space at JPL") represent a modern compact technique for storing large amounts of information.

A generic approach to the problem of data storage and subsequent retrieval-on-demand is being undertaken at JPL in the form of two projects: the Pilot Planetary Data System (PPDS) and the Pilot Ocean Data System (PODS).

The PPDS project, managed by Dr. Arthur Lane, who has also been closely associated with the Voyager Project, has been examining the relative merits of the two types of video discs, analog and digital. The project is particularly interested in further developing the technology of digital discs because of their greater intrinsic storage capacity and greater accuracy of reproduction. However, digital discs currently require larger develoment costs. The JPL task is being executed in conjunction with several universities, and a goal is to develop the system to the state that users will not have to be present at JPL but can access the data from their own work stations.

The PODS project, managed by J.C. Klose, focuses upon the problem of storing and retrieving the oceans of data returned from JPL's 1978 Seasat oceanographic satellite. Direct computer access to these data constitutes a significant improvement over the method of mailing magnetic tapes to researchers. In addition to data distribution, PODS is concerned with designing tools for analysis of the data and providing a computerised bibliography of the literature of remote sensing of the oceans.

The video-disc playback system at JPL's Regional Planetary Image Facility (a photographic mural of Jupiter's Red Spot as seen by Voyager is in the background). Disc technology permits quick access of data by the user and compact storage of large numbers of images.

SOCIETY NEWS

NEW DISPLAY CERTIFICATES

From time to time members have written in to ask the Society to make available larger and more pleasing membership certificates suitable for framing and display, particularly as the certificate required by law and sent on election is not really satisfactory.

The Council has now arranged, as one of our fund-raising measures, for new and improved certificates to be available shortly. They will be in A4 size, printed in two colours and incorporate the Society's newly-adopted seal, based on our logo.

They will be signed by the President of the Society and the Executive Secretary, as hitherto, but back-dated to show the original date of election to the appropriate membership grade. This may not always be the original date of election to membership but *two* certificates can be purchased, if desired, one quoting the date of election to the original grade and the second giving the date applicable to the current grade. These new certificates will cost £5 post free.

AN IMPORTANT NOTICE TO ASSOCIATE FELLOWS

As part of its review of the Society's Constitution and in moving towards an application for making a Royal Charter, the Council determined that elections to the grade of Associate Fellow be discontinued with effect from 31 December 1983.

Two further extremely important changes have also been made:

a. All Associate Fellows listed at that date will now automatically be re-graded as Fellows. Existing Associate Fellows have been notified by letter of this change so there will be no need to make individual applications. Since the subscription payable by both Associate Fellows and Fellows was standardised at the same amount several years ago, no financial changes are involved.

b. In future, transfer from Member to Fellow will be direct and based on technical qualifications or a long-standing support of the Society's objectives. To facilitate this, Members who have continuously been with the Society for a period of not less than ten years may now be eligible for transfer to Fellow. This relaxes one of the existing rules and now recognises that many of our long-standing Members are among the strongest supporters of our work.

Existing Members or Fellows, including those recently transferred from the Associate Fellow grade, who would like to have a Certificate suitable for display are referred to the note elsewhere in this issue.

These changes are reflected in the Society's Constitution which is now in an advanced stage of revision and which will be submitted to members for approval and adoption shortly.

The Society's addressing records will be altered to give effect to this re-grading shortly.

PAYMENT BY CREDIT CARD

To assist further those members of the Society who wish to take advantage of the growth of credit card facilities nowadays, the Council has confirmed that payment by ACCESS and VISA will both be acceptable with effect from 1 May 1984.

These new arrangements will apply to subscriptions, saleable items, registration fees for meetings and any other financial matters involving the Society.

BONESTELL EXHIBTION

An exhibition of Chesley Bonestell (BIS Fellow) paintings was exhibited recently in Japan, at the Sibu Museum of Art in Tokyo, followed by a tour to many other Japanese centres over a six month period. The exhibition was supprted by a beautifully-produced colour catalogue, the sale of postcards, posters, etc.

The display had appeared earlier in a tour of many major American cities, science centres, and planetaria and had also visited Australia and Indonesia. All of 50 of the paintings have their permanent home with the Alabama Space & Rocket Center in Huntsville, USA.

APPOINTMENT

We are pleased to record that Dr. David Smith, Associate Fellow, has been appointed Associate Editor of the internationally-respected astronomy magazine *Sky and Telescope*. Dr. Smith, previously in the Dept. of Physics at Queen Mary College in London, is a member of the Editorial Board of the Society's *Space Education* magazine. His past work ranges from photometry of BL Lac objects, to the theory of lunar occultations.

MOON ROCKS VISIT

Thirty-five members of the Society journeyed to the City of London Polytechnic on 26 October 1983 to attend a lecture-demonstration on Moon Rocks by Professor R. Skelhorn, Head of the Department of Geology.

The Proceedings opened with a pleasant surprise, the provision of refreshments all round, accompanied by handouts giving background material to the lunar materials and the Moon itself.

Things augured well on arrival. The first sight was a massive ammonite, some 40 cm across and 22 cm thick, apparently serving as a door stop.

Professor Skelhorn welcomed us, not only pointing out that it was *our* 50th Anniversary but also saying that it was his, too! He was intrinsically a geologist interested in the Moon from the point of view of similarity with volcanic rocks occurring on Earth. Much of his talk was a discussion on how the lunar craters had been formed, i.e. the cycle of events which would follow a meteoric impact. Probably, there had never been any water on the Moon, with the result that the number of mineral specimens is restricted. One characteristic feature is that lunar basalts contain more titanium than the basalts on Earth i.e. up to 11% compared with 3%. The rilles are of particular interest. Some were probably roofed originally, i.e. lava tubes. The lava had flowed underground though the roofs had subsequently collapsed.

A diagram distributed to those attending speculated on various lunar formations over astronomical time. There

with ejecta from craters with lava flows forming the Maria, occurring subsequently. The meteoric bombardement had continued for some time afterwards, *albeit* in a much-reduced form.

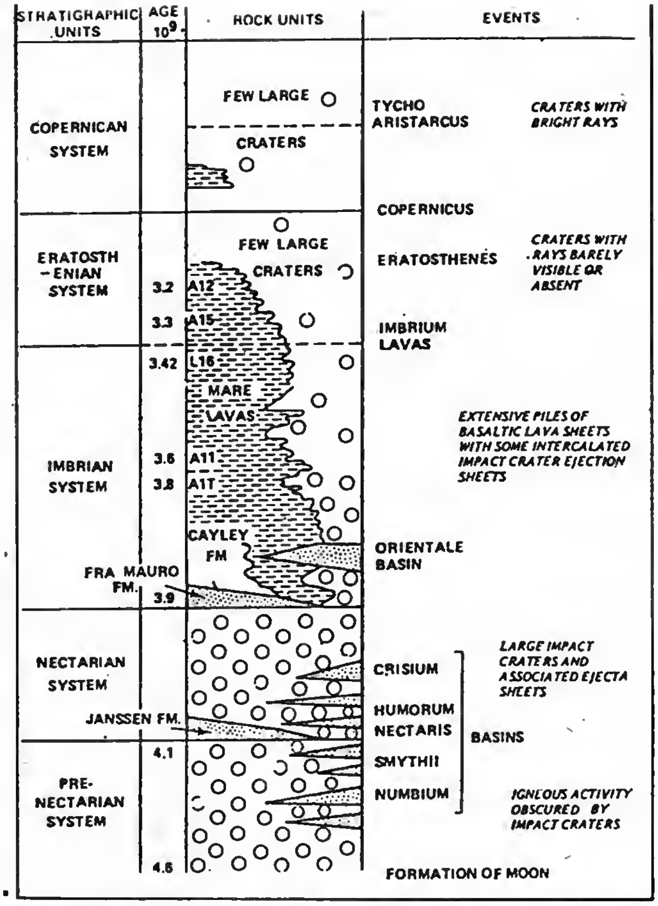
The Moon has been a very quiescent body for the last 3,000 million years, unlike the Earth which is still a dynamic evolving body.

Replying to a suggestion that the Earth, during the equivalent period, had a viscous surface which absorbed meteoric impacts, Professor Skelhorn said that the oldest dated rocks on Earth were formed some 3.8 billion years ago, wheras the large-scale lunar activity was about 3.9 billion years ago.

The talk was interspersed with many examples of dry humour e.g. when referring to the Maria, now known to be formed of basalt, he said that it was once argued that they were really pitch, which would make them the largest potential car parks in the Solar System. On the lunar atmosphere he said that, if made comparable to that on Earth, one could probably get it all inside a house in Eastbourne!

After this talk the party moved downstairs to examine the lunar and meteoric display set up in a separate room. This included a battery of 20 illuminated microscopes with turntable platforms on which were mounted slivers of actual Moon rock, with descriptive text by the side and flanked by several photographic displays and meteor specimens. Professor Skelhorn moved among his charges to answer questions and to add further words of explanation where desired, aided and abetted by Dr. D.J. Horne, a member of the Society's Education Committee who was also based at the Polytechnic.

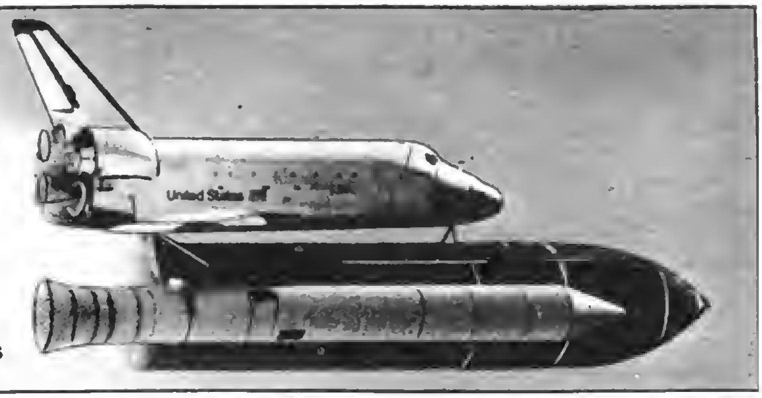
L.J. Carter



Observing samples the hardway: John Young scoops up lunar soil during the Apollo 16 mission. *Inset:* BIS members observing Moon samples the easy way.

SPACE REPORT

A monthly review of space news and events



GRAVITY PROBE

NASA's Gravity Probe-B Relativity Gyroscope programme will provide two completely new tests of Einstein's theory of gravitation — General Relativity — which is the basis of our current understanding of the Universe.

According to Einstein, gravitational forces act not through direct attraction between bodies, but as the result of a "warping" of space-time. Unfortunately, Einstein's theory is very poorly tested experimentally, writes Gerald Borrowman.

Over 20 years ago a gyroscope satellite experiment was conceived as a test of General Relativity. It was based on the expectation that an extremely precise gyroscope on Earth should precess (change its direction of spin) for two reasons: because of its motion through the warped space-time; and through an effect known as the "dragging of inertial frames" in which the rotating Earth drags space and time around with it.

Gravity Probe-B will consist of three major components: The scientific instrument, a large liquid helium dewar which houses the main parts of the instrument, and the spacecraft, which provides the mechanical support, power supply, communication and attitude control.

During 19B3 the preliminary design was evaluated at NASA Headquarters. The contract was to be awarded during the final months of 1983. On approval a three-year instrument development programme will begin in 1984. In late 1987 fabrication of the flight instrumentation will begin, followed by the dewar and spacecraft. Launch is expected for 1991 or 1992.

SPACE TELESCOPE RENAMED

The Space Telescope, the large orbiting optical astronomical observatory due for launch in 1986, has been renamed the Hubble Space Telescope in honour of the distinguished astronomer. Dr. Burton Edelson, NASA's Associate Administrator for Space Science and Applications and a BIS Fellow, announced the renaming.

Edwin Hubble's astronomical research over three decades profoundly changed our understanding of the basic structure of the Universe. Before Hubble, scientists held differing views on the extent and dimensions of the Universe. It was believed that our Solar System was part of a larger system which contained all the stars visible to the naked eye. Astronomers were uncertain whether the faint spiral nebulae were also part of our Milky Way system or themselves distant galaxies.

Working at the 2.5 m telescope at Mount Wilson in California, Hubble succeeded in observing individual stars in the Andromeda nebula. By the end of 1924, he was able to show that Andromeda was many times more distant than any star within the Milky Way system. By means of similar observations of other nebulae, Hubble established that these nebulae were in fact galaxies far beyond our own system.

Equally important was a later discovery by Hubble that the Universe is expanding, providing the basic evidence of the Big Bang theory.

Hubble was an active research scientist until his death in 1953.

The Hubble Space Telescope will be operated much like a ground-based observatory. The 2.4 m telescope and five scientific instruments will be housed in the observatory in orbit while command, control and scientific operations will be ground-based. The observatory, which will not have any interference introduced by Earth's atmosphere, will be able to look into space seven times farther than any ground-based observatory, and its imaging will have 10-20 times better resolution.

FRENCH ABOARD THE SHUTTLE

US astronauts will use a French-built blood monitoring instrument aboard the Shuttle missions this year, possibly leading to a French cosmonaut flying in 1985/6.

When Jean-Loup Chretien spent a week aboard the Soviet Salyut 7 space station in 1982 he used an "echography" device to monitor blood flow in the body under conditions of weightlessness. The instrument is believed still to be in use by Soviet cosmonauts.

It now appears that a flight to Salyut 7 by Patrick Baudry, Chretien's backup during the 1982 mission, will not take place. Discussion between Soviet and French planners have ended.

ARIANE DELAYS

The eigth launch of Ariane, due to have taken place in December, has been slipped to the second half of January to allow engineers time to evaluate the condition of the satellite carried aloft by the seventh launch on 18 October.

Even before the Ariane L7 flight, Intelsat engineers were concerned over noise appearing in communications links with their Intelsat 5 F5 satellite already in orbit. L7 was also delayed before the go-ahead was given for it to carry Intelsat 5 F7 into space. The LB launch will carry the FB craft.

The delay will give Ariane engineers the opportunity to make minor modifications to the launcher's third stage oxygen pump.

Douglas Arnold (BIS Fellow) captured this excellent picture of Shuttle "Columbia" with Spacelab as it rose over Havant in Hampshire on 28 November 1983 before entering the Earth's shadow at 17.54 GMT (just 1 h 54 m after launch from Cape Canaveral). Its brightness can be judged from the bright star Vega (magnitude 0.0) at top left. A Nikon F3 camera with an f2.8 24 mm wide angle lens was used with Kodak Tri-X film for a one minute unguided exposure.
Space Frontiers Ltd.

Following the slippage in late October, the Ariane L9 flight (with Intelsat 5 F9) was scheduled for March 1984; and Ariane L10 (with the Spacenet and either ECS 2 or Telecom 1A communications satellites) for the second half of May. The latter launch will introduce the Ariane 3 version, with boosters.

SHUTTLE LIGHTING

Working close in to other satellites in orbit during dark periods is a problem for the Shuttle and other spacecraft. Plans are now avanced for testing a quartz-iodide spotlight aboard STS-11 mounted on the cargo bay forward bulkhead, behind the crew compartment. Tests have also taken place with 150 W and 300 W xenon lights for later use aboard the Shuttle, illuminating targets up to 300 m away.

VOLCANIC ACTIVITY ON VENUS

Evidence of possible volcanic activity on the planet Venus has been discovered with an ultraviolet spectrometer on NASA's Pioneer Venus spacecraft.

Nearly continuous observations of the atmosphere of Venus since 1978 by the Pioneer Venus spacecraft have revealed large quantities of sulphur dioxide and sulphuric acid haze at the cloud tops, a possible indication of volcanic activity on the surface of the planet. Venusian clouds have no visible features at the wavelengths of visible light but, in the ultraviolet, dark markings indicate upwellings of sulphur dioxide.

The observations showed a decrease of more than 90 per cent in the sulphur dioxide content of the cloud tops during the past five years, suggesting a major volcanic eruption on the surface before the arrival of the spacecraft in 1978. It is estimated that an eruption with at least 10 times the energy of recent volcanic activity on Earth would be required to hurl sulphur up to 70 km into the Venus atmosphere.

The Pioneer Venus radar mapper has provided additional evidence of possible volcanic activity on Venus by identifying topographical features which resemble terrestrial volcanic regions. Lightning has also been observed near these regions on Venus (on Earth, lightning frequently accompanies volcanic eruptions).

Venus has often been called Earth's sister planet because of the resemblance in both size and the amount of sunlight falling on its surface. These observations may lead to a better understanding of both the volcanic processes on Earth and the evolutionary histories of the two planets.

The radar mapping instruments aboard the Soviet Venera probes, circling Venus since last October, may provide further evidence of volcanic features.

INFRARED TELESCOPE TESTING

Final assembly of the small Helium-Cooled Infrared Telescope for the Spacelab 2 flight in 1985 has been completed and testing is under way, according to engineers at the Marshall Space Flight Center. The telscope is one of 13 experiments that will make up the Spacelab 2 mission (which will fly *after* Spacelab 3).

The major elements of the telescope, including a 250 litre liquid helium container (a "dewar") and a cryostat that contains a telescope capable of mapping large areas of diffuse infrared radiation, were assembled by the Marshall Center's Test Laboratory.

The dewar, which will contain liquid helium at a temper-

NASA's CHALLENGE

President Reagan challenged NASA during a speech at the National Air & Space Museum in Washington D.C. on 19 October to provide more challenging targets. Speaking to mark the space agency's 25th anniversary, he said, "I would like to challenge you at NASA and the rest of America's space community: Let us aim for goals that will carry us well into the next century."

George Keyworth, the President's Science Advisor, said that NASA should consider a return to the Moon and the manned exploration of Mars.

NASA, however, were *still* waiting for Presidential approval for the Space Station project. Keyworth has been an opponent of a permanent manned station. Space planners see a station as the first step in a series of projects such as lunar bases and, later, exploration of the planets.

SPACE SICKNESS INSTITUTE

A new research institute at the Johnson Space Center in Houston has been set up to look at the problems space crews have in adjusting to weightlessness in space. The NASA Space Biomedical Research Institute will work as part of the Space Adaptation Project within the Space Transportation Systems Program Office, which manages the Shuttle.

The "Space Adaptation Syndrome" is the range of effects that astronauts sometimes experience, including nausea, vomiting and general malaise. About 45 percent of astronauts have suffered in flight.

Some flight data have been collected over the past 23 years of manned space flight, particularly during the extended Skylab missions. Experiments have been performed on Shuttle flights with physician astronauts Dr. Norman Thagard on STS-7 and Dr. William Thornton, the principal investigator and designer of much of the experimental hardware and research, on STS-8.

To speed up the process of finding counter-measures, NASA has established the institute.

IRAS : ANOTHER DISCOVERY

The orbiting telescope on the Infrared Astronomical Satellite (IRAS), which discovered five new comets in four months last summer, has discovered another unusual member of the Solar System. While examining the satellite data of 11 October Simon Green, a postgraduate student in astronomy at Leicester University, noted a rapidly moving object that was observed by the telescope in seven consecutive orbits spaced 100 minutes apart. The news was immediately flashed to observatories around the world and the object was quickly located and photographed by the Palomar Observatory in California and the Lowell Observatory at Flagstaff in Arizona, who reported that it appeared to be a very dim, 16th magnitutde asteroid.

From the object's position in the sky at the three times it was seen, Brian Marsden of the International Astronomical Union calculated its orbit and determined that it belongs to the family of Apollo asteroids which have orbits that take them closer to the Sun than the Earth. It has been given the temporary designation of minor planet number 1983TB. It appears to be less than 2 km in diameter, and it was about 30 million km from Earth when first observed.

An Indian cosmonaut will fly aboard a mission to the Salyut 7 space station next April. Sqn. Ldr. Rakesh Sharma (right) will make the trip; Wing Cdr. Ravish Malhorta (left) is his backup. Discussions on Frenchman Patrick Baudry occupying a Soyuz seat appear to have concluded with no mission assigned.

There are many "Earth-crossing" asteroids and a new one is discovered every few months, but it was immediately apparent that 1983TB was of exceptional interest. It passes within 15 million km of the Sun, closer than any planet or other known asteroid and ten times closer than the Earth. Furthermore, its orbit is almost exactly the same as that of the Geminid stream of meteoroids which are visible as a shower of meteors in December.

Astronomers have known that several meteoroid streams move along the orbits of comets, the material apparently having been shed by the comet over the centuries. Thus the Orionid shower in October is associated with Halley's comet, and the Perseid shower in August is apparently related to the short-period comet Swift-Tuttle.

Comets are believed to be composed mainly of ice, mixed with dust and rocks, whereas asteroids are miniature planets of mainly soil and rocks. Although 1983TB look like an asteroid in a telescope, its apparent relation to the Geminids suggests that it might actually be a dead comet which, having passed so close to the Sun many times, has had all the ice and other volatile components boiled out of it. On the other hand, it is somewhat larger than the nuclei of most comets are believed to be, and its aphelion (the point in its orbit farthest from the Sun) is right in the asteroid belt beyond Mars.

The orbital period of 1983TB is about 1.5 years and its plane is inclined about 20 degrees to the Earth's orbit.

UK INVOLVEMENT IN SPACE

An agreement was signed in Bonn, W. Germany last October to allow British scientists to take part in two space science projects with German and US colleagues.

The first, AMPTE (Active Magnetospheric Particle Tracer Explorers), will study space plasma physics. It will investigate how solar energy, carried by the solar wind, is intercepted and stored in the magnetic fields as charged particles that form the Earth's radiation belts and the other parts of the comet-shaped magnetosphere surrounding the Earth out to distances of more than 100,000 km. The stored energy ultimately becomes deposited in the upper atmosphere, mainly at high latitudes, where it produces heating, ionisation and the spectacular phenomenon of the Aurora Borealis.

The AMPTE mission, planned for launch in August 1984, consists of three satellites which will be launched

on a single Delta rocket. One satellite being built in Germany will release lithium ions into the solar wind at distances of around 20 Earth radii to act as tracers. A US satellite, orbiting closer to the Earth, will detect the arrival of the ions and note the extent of their expected increase in energy. Seven releases of lithium and barium are planned for various points along the route taken by the solar wind ions and electrons. The small UK spacecraft, known as UKS, will be a sub-satellite of the German craft which it will track in tandem along the same orbit. These two satellites will investigate with high resolution the wide range of phenomena caused by the released ions and electrons and so add an extra dimension to the mission. Throughout most of the approximately one-year mission the three spacecraft will also study the natural particles, fields and waves of the magnetosphere. UKS is approximately 1 m in diameter, with two pairs of booms, and weighs 74 kg.

The second agreement concerns the German Rötgensatellit (ROSAT) which will carry a German 0.8 m X-ray telescope and a UK Wide Field Camera (WFC). The latter is a novel design of telescope optimised for the soft X-ray/Extreme Ultraviolet band, being provided by the UK.

The power of X-ray imaging optics, first used for cosmic astronomy in NASA's Einstein Observatory satellite (1978–81), added hundreds of new sources to the catalogues, ranging over a wide variety of objects. However, the Einstein observations were restricted to a narrow spectral bandwidth and to a few percent of the sky. ROSAT's telescopes will greatly enhance those observations. The German telescope will survey the whole sky with a sensitivity comparable to that of the deeper Einstein observations, while the British WFC will extend the energy band of the observations threefold, reaching well into the extreme ultraviolet.

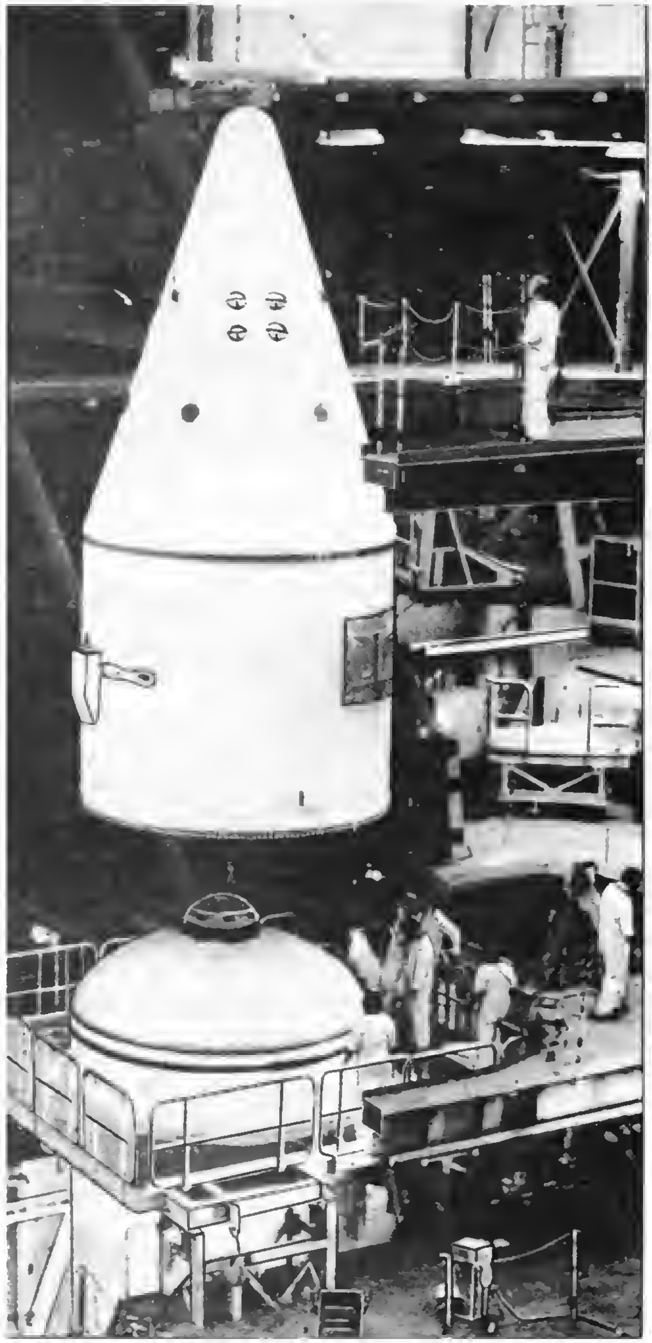
There are two main mission objectives. First an all-sky survey will be made during the initial six months in orbit, at a level two orders of magnitude deeper than the best existing all-sky surveys. The second phase, lasting up to 2½ years, will allow for detailed observations of individual X-ray sources and source fields using the accurate pointing capabilitry of the satellite. In this phase the German and British telescopes will be used to obtain accurate X-ray source maps and spectral and timing data which will greatly extend current knowledge of the high temperature and relativisitic phenomena in situations as diverse as stellar coronae, supernova remnants, compact accreting binaries, galaxy clusters and quasars with extreme redshift. Data from the WFC will be of particular interest since its covers the Extreme Ultraviolet (XUV) band, the last, 'unexplored' region of the spectrum, and one that only a few years ago was considered (forever) inaccessible, due to the opacity of the interstellar medium.

NASA will provide some instrumentation for the German telescope and will launch ROSAT on the Space Shuttle in August 1987. It will probably be the only large X-ray telescope in operation during the latter half of the 1980's and its data are expected to have a major impact on astronomy well into the next decade.

GAMMA RAY OBSERVATORY

The Soviet Union is planning to launch a modified version of its Progress unmanned Salyut space station ferry vehicle next year carrying a gamma-ray telescope.

The 1500 kg Gamma 1 payload was to have been sent into orbit this year but technical difficulties have forced a rescheduling to mid-1985.



A view of the Space Shuttle boosters not seen before in *Spaceflight*: removing the top section from the propellant segments. This is the right hand booster from the STS-9/Spacelab 1 stack which was returned to the VAB from the launch pad in order to replace the nozzle after a suspect lining was discovered. The lining almost burned through on the STS-8 launch in August. *NASA*

Soviet scientists also recently confirmed that their two Venus-Halley probes due for launch on 24 and 28 December 1984 will release balloons into Venus' atmosphere. The 4 m balloons will be tracked from Earth to provide information on atmospheric motion, while two landers will descend to the surface. The flyby sections will later encounter Halley's comet.

Discussions are continuing between French and Soviet scientists on plans for missions to Venus in 1990/91. These include ballistic atmospheric probes and balloons circling the planet in the atmosphere. Plans are also afoot for French cooperation in a Soviet lunar orbit for 1987-90.

PLEASE NOTE: We would like to note that the picture of the Indian SLV-3 rocket used on p.455 of the December 1983 issue was by kind courtesy of The Science Museum, London.

The Latest Developments from Cape Canaveral in Florida

By Gordon L. Harris

SPACE PIONEER DIES

The engineer-manager who conceived the Kennedy Space Center, the national spaceport for the United States, died on 10 October 1983 of heart failure after several years of illness.

He was Kurt Heinrich Debus, born 29 November 1908 in Frankfurt Main, Germany, who studied electrical theory and techniques at Darmstadt University where he received a Ph.D. degree and taught as an assistant professor. There he was recruited for the Peenemuende Research Center by Dr. Wernher von Braun. With 125 colleagues he surrendered to the US Army as World War II drew to a close.

Debus launched V-2s at Cuxhaven for the British before rejoining his team at Fort Bliss, Texas where they remained until 1949. They assembled and launched V-2s under Army auspices at White Sands Missile Range in new Mexico, exposing to military and industrial onlookers the basic technology developed at Peenemuende. After the required five years residence they opted for US citizenship.

In 1950 they moved with families to Huntsville, in northern Alabama, where the Army planned a rocket development complex at Redstone Arsenal. Their first task involved the Redstone liquid fuelled ballistic missile system destined for NATO deployment. Derived from German experience, the rocket could transport a warhead weighing three tonnes 200 miles.

In due course Debus became director of a Missile Firing Laboratory operating on Cape Canaveral, Florida. From then until his retirement in 1974 he directed launches of 288 vehicles: Redstone, Jupiter, Juno, Jupiter C, Pershing and Saturns 1, 1B and 5.

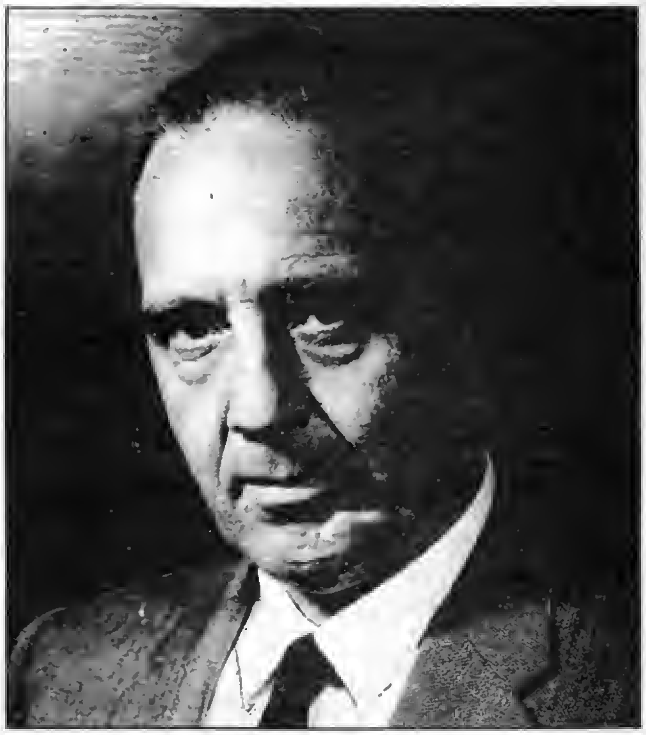
Following the launching of Sputniks 1 and 2 by the USSR in 1957, Debus supervised the launch of Explorer 1, first American satellite, on 1 February 1958 (GMT). In 1961, using a similar Redstone booster, he launched Alan Shepard and Virgil Grissom, the first US astronauts.

After President John Kennedy announced the programme to land men on the Moon, Debus was instrumental in selecting north Merritt Island, adjacent to Cape Canaveral, as the major site for Apollo. He also conceived the mobile concept which sheltered most checkout and assembly operations in a giant hangar before transferring the space vehicle to launch pads near the Atlantic Ocean shoreline.

The huge complex was ready when Saturn 5s began arriving for the assault on the Moon. The ambitious undertaking reached a climax on 16 July 1969 when Apollo 11 began its historic journey culminating in the first landing.

After Apollo, Debus supervised preparations for Skylab, the first large space station, occupied by three astronaut crews in 1973-4. He broke ground for a Shuttle landing strip in the latter year before announcing he would retire. High blood pressure, physicians warned, would be fatal if he did not leave his post. He had completed 30 years of service to the US Army and NASA and had received awards and decorations from his adopted country as well as his native land.

After a short period of rest he accepted the post of board chairman for OTRAG, the West German privately-financed firm that set out to build inexpensive boosters for commercial space applications. Three rockets were fired in Zaire before pressure from the Soviet Union, Germany and France persuaded Zaire's dictator to stop the launchings. The firm looked about for another site, meanwhile considering shipboad launches in international waters, but Debus withdrew.



He suffered a second aneurism and kidney failure. Dialysis carried him through that setback and he was able to witness the first launch of *Columbia* in 1981. Thereafter he rarely left his waterfront home on the Banana River in Cocoa Beach.

KSC Director Richard Smith hailed Debus as a "true pioneer and a leader in US space programs." Mrs. Gay Debus and two daughters, Ute and Sigrid, survive.

SPACELAB DELAYS

Embarrassed by continuing Shuttle problems, NASA persuaded the European Space Agency to accept the 28 November launch date for Spacelab 1 on the heels of two postponements. ESA initially preferred to delay the mission until February 1984 which would have involved even more costs to NASA and forcing other re-scheduling of future missions. The decision came on 2 November following a conference between Administrator James Beggs and ESA's director, Erik Quistgaard.

"NASA management confirmed that the Shuttle system is ready to support the November date following the change of a solid rocket motor nozzle assembly," said a

30 September launch, then delayed it to 28 October and stopped work on 14 October while *Columbia* was on Pad 39A because of defective exhaust nozzle lining on the right hand Solid Rocket Booster. *Columbia* was removed from the pad, demated and taken back to the Orbiter Processing Facility where its fuel cells were taken out and replaced with new cells borrowed from *Discovery*, the third orbiter, whose delivery was postponed until 9 November.

NASA sources said a February mission was rejected after a majority of scientists responsible for Spacelab experiments preferred the November flight. Of 38 experiments, 26 were sponsored by ESA and 12 by NASA. The US agency played its best bargaining chip by offering flight opportunities on future shuttles for five, or seven, Spacelab 1 experiments. These missions could begin in November 1984 and extend to mid-1985. Wilfred Mellors, ESA's representative to NASA, said agencies and experimenters involved in repeat flights will probably assume their own costs.

Herman Kurscheid, ESA payload manager, identified the European experiments eligible for re-flight as:

1. Grille Spectrometer to investigate the atmosphere at 14 to 150 km altitutde (Belgium);
2. Study waves in oxygen-hydrogen compound emissions in the atmosphere (French);
3. Very wide field camera to conduct an ultraviolet survey of large scale phenomena (France);
4. Metric camera testing high resolution mapping capability (ESA).

Two others may be candidates. One is a biostack experiment to study the radio-biological importance of cosmic ray particles. The other is a study of microorganisms and biomolecules in the hard space environment. Both are German contributions.

SPACE STATION PROPOSALS

Mindful that former Vice President Walter Mondale stoutly opposed its Shuttle programme, and is now the leading candidate for Democratic nomination for the presidency, NASA has launched a drive to acquire a permanent space station while President Reagan occupies the White House.

A spokesman for the agency's 250 member Space Station Task Force told the Budapest IAF conference in October that planners have identified 107 missions for such a station. Assembled in orbit from sections carried up in Shuttles, the facility would become a departure point for deep space journeys and a service station for satellites needing repair.

E. Lee Tilton, deputy director, National Space Technology Laboratory, and E. Brian Pritchard of Langley Research Center co-authored the paper. NASA's task force has described 48 scientific, 28 commerical and 31 missions for technology development during the 1991-2000 period. Costing from $7 to $9 billion, a station could be in operation by 1992, the task force said. A larger one housing 12-18 astronauts would cost $17-$20 billion.

While President Reagan is supposedly favourably inclined, advisers have urged delay because of mounting budget deficits. Repeated Shuttle delays and cautious response from potential industry users have strengthened the opposition.

JANUARY JOURNAL

The first of 1984's issues of *JBIS* is unique, devoted to the most famous comet of all time: Comet Halley. Demand for this issue is heavy so buy now to be sure of your copy.

Five papers present an exhaustive overview of the next apparition of Halley's Comet. In two papers, Dr. David Hughes of Sheffield University describes the comet on its past appearances and Halley the astronomer. Rod Jenkins of British Aerospace gives a detailed review of Europe's Giotto probe, now being built in England at Bristol. Ray Newburn of the Jet Propulsion Laboratory in California describes the International Halley Watch, and Janet Dudley of the Royal Greenwich Observatory looks at popular reactions to the comet's last visit.

The issue is available now at a cost of £2 ($4) per copy from The British Interplanetary Society, 27/29 South Lambeth Rd, London SW8 1SZ.

February *JBIS* is devoted to "Space Technology," with most of the papers originating from the 18th European Space Symposium last June.

BADGES

A range of badges with the Society's motif is available.

Enamel lapel badges (1 in. diameter) and cloth blazer badges (3 in. diameter) cost just £1 ($2) each.

A special metal car badge adds that distinguished look to any vehicle for only £3 (£3.50 or $7 abroad).

LASERS IN SPACE

The use of lasers in space is frequently given somewhat sinister overtones by the military implications. Clive Simpson considers instead the impact on the civilian side of space exploration and development.*

Introduction

Deepening interest in high-power lasers expressed both by members of the United States Congress and NASA advisory committees led in October 1980 to the setting up of the NASA High-Power Laser Working Group. The group's main task was to assess the current NASA laser research programme in the context of potential civilian and military applications and recommend a balanced programme that would complement the research efforts of the Department of Defense (DOD) and the Department of Energy (DOE), and provide a strong technological base for future civilian space applications.

Studies carried out on the potential of high-power lasers have consistently identified highly rewarding possibilities, such as the beaming of power in space, spacecraft propulsion and deep space communications. Such applications are often cited as ways of reducing the sometimes daunting cost of more conventional space power and propulsion, an essential step before the full development of near-Earth space can begin.

Applications

A major use for high-power lasers would involve the generation of large amounts of energy in space (or on Earth), its transmission over long distances and ultimate conversion for power and propulsion.

Lasers have an unparalleled capability for transmitting energy in space because of their small beam divergence and short wave-lengths. The chance to exploit this has motivated studies of solar-power satellite (SPS) systems, in which the power is beamed to Earth using lasers rather than microwaves.

In one such study the total costs for laser and microwave transmission were comparable, but the area required on Earth for the receiver was 40 times less for the laser system compared to the microwave.

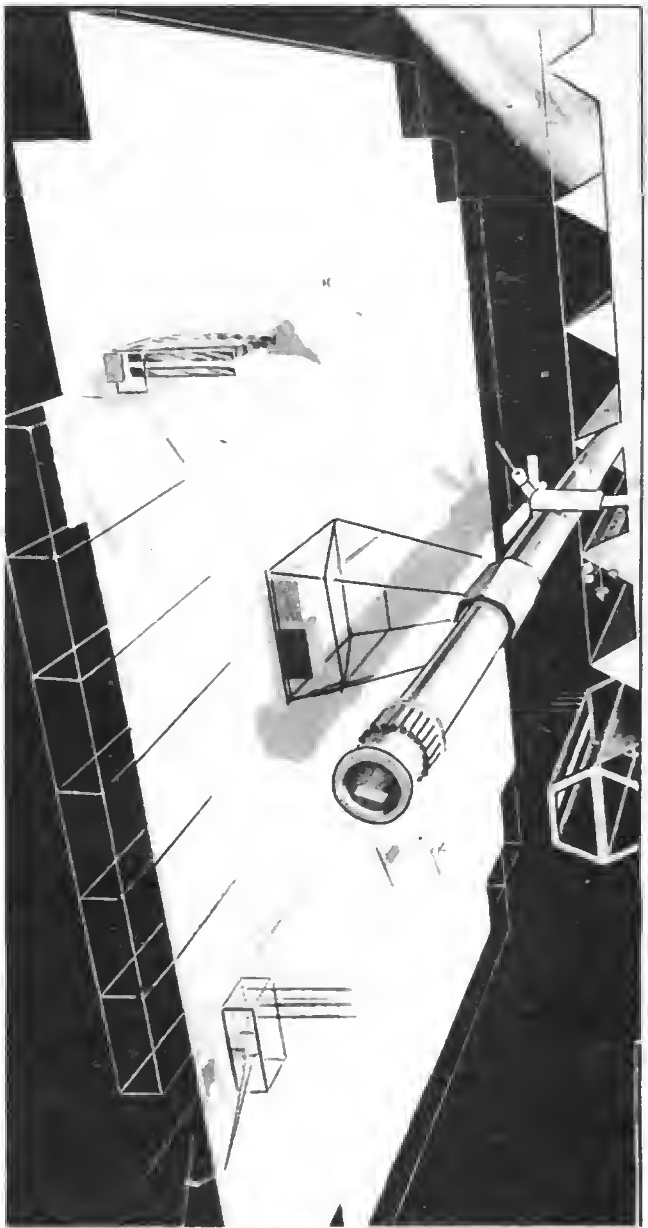
Similarly, the beaming of power from a large central power station to orbiting vehicles seldom shows significant cost savings but it would allow dramatic changes in the design of the receiving spacecraft.

For instance, large arrays of solar cells could be replaced with a relatively small laser beam collector, dramatically reducing the overall size, mass and control system needs of the spacecraft.

The large central power station beaming power to remote users is one of the most extensively studied potential uses of the high-power space laser.

Three power station concepts — an electric discharge laser powered by photovoltaic array, a solar-pumped laser, and a nuclear-pumped laser as an integral part of a gas core reactor, (each producing a beam power of 100 MW) — have been suggested. All three designs are large and would probably involve comparable levels of difficulty in terms of deployment and construction in space.

* *Based on "A NASA High-Power Space-Based Laser Research and Applications Programe," NASA SP-464, 1983.*



Laser transmission is an alternative to microwave systems for beaming power down to Earth from orbiting Solar Power Satellites. NASA

The photovoltaic electric-discharge laser (EDL) is dominated by a solar cell array, the solar-pumped laser by a solar reflector, and the nuclear-pumped laser by the radiator array needed to dissipate excess heat produced by the reactor. Of the three systems, the technology for the photovoltaic EDL is by far the most advanced and such a system could probably be built, although it would be relatively expensive.

The nuclear-pumped laser has also received considerable study and a fairly strong technological base exists for both the laser and the gas core reactor as individual systems. However, what has not yet been demonstrated is the integration of the reactor and laser into a single unit.

This is obviously a crucial step for the space-based nuclear laser power station and would require a level of funding well beyond the scope of any foreseen NASA programme in high-power lasers.

The solar-pumped laser idea is the newest of the three concepts and although both a solar-pumped laser and a blackbody-pumped gas laser have been demonstrated in the laboratory the technology is still at a very early stage of development.

In other studies the costs of supporting an early space

industrialisation scenario featuring the heavy transfer of materials from low Earth orbit to geosynchronous orbit have been compared for an advanced chemical Orbital Transfer Vehicle (OTV) and an OTV using a laser-thermal propulsion system. The transportation cost for the laser-thermal OTV, including the cost of the central laser power station, was half that calculated for the chemical OTV.

One design for laser-thermal propulsion envisages the laser light being focused into the thrust chamber of the rocket where it heats a gas which is then expelled through a conventional nozzle to produce thrust.

Although most studies of laser power beaming have considered very high power beam systems there are also some interesting applications at modest power levels. For instances, research has shown that a solar-pumped laser producing beam power of only 100 kW would need a collector with a diameter of just 42 m and could weigh as little as 10,000 kg.

Such a system might be used on a manned space station to beam power to nearby free-flying spacecraft, which would act as platforms for materials science processing experiments that could not tolerate the immediate environment of a large space station.

A laser receiving mirror of only 8 m would be needed on the free-flyer and this, combined with a 50 per cent efficient solar-to-electric conversion system, would provide 50 kW of electrical power. By contrast, the free-flyer would need a cumbersome 8 by 80 m photovoltaic array to provide similar power levels.

Long distance space communication is another potential use for modest power lasers. With its small beam divergence the laser could pinpoint regions of deep space much smaller than those that can be investigated by microwave.

Lasers use much less power and vehicle communication over long distances within the solar system could be much more cost-effective.

The NASA Laser Programme

For power beaming applications NASA must develop efficient, continuous, light-weight, low cost lasers. DOD-DOE lasers, however, tend to be pulsed or have a very short run time, producing concentrated bursts of radiation for target location or destruction. NASA's interest is in more efficient conversion of laser radiation to thrust, electrical or storable energy.

It was decided in 1979, as a result of a series of workshops and conferences, that the limited funds available for the NASA programme could be best utilised by phasing out the work on conventional electrically-pumped and nuclear-pumped lasers to concentrate on research on solar-pumped lasers. The logic behind this was to bring the technological base for solar-pumped lasers, which although simpler are probably as efficient as electrically-pumped lasers, to a level of definition comparable to the others.

The 1982 NASA laser programme consisted primarily of research on solar-pumped lasers, with modest efforts on high-efficiency converters and laser propulsion.

There are a number of key technology barriers still to be overcome if the full potential of space-based high-power lasers is to be realised, and the programme is designed to concentrate on these. It is not hardware-orientated but it is designed to investigate the potential of high-power lasers in NASA missions and to develop the technology for space-based laser systems.

ESA's NEW SATELLITE STUDIES

As reported on p.138 of last April's *Spaceflight*, the European Space Agency selected five scientific satellite proposals for their studies. These were: First (an infrared and radio telescope); XMM (an X-ray observatory); SOHO (a solar observatory); Cluster (four satellites in the Earth's magnetosphere) and Agora (an asteroid probe). The assessment studies were published the following September to provide a basis for further discussion; one of the satellites might fly at the end of this decade.

First

The submillimetre wavelength region is the last major window in the electromagnetic spectrum left unexplored. It is sensitive to phenomena characteristic of the 'cool' Universe, ranging from star formation in molecular clouds to the expansion of the Universe.

The instrument proposed is the Far-Infrared and Submillimetre Space Telescope (First). This is an orbiting telescope radiatively cooled to a temperature of 150 K, with an aperture of 8 m and operating at wavelengths between 0.1 and 1.0 millimetre. The telescope, radiation shield and solar arrays will be deployed after launch. At 0.1 mm it overlaps with the window explored by the IRAS and ISO (recently selected by ESA for building later this decade) satellites; the ability of First to expand on the results obtained by these observatories adds to its value.

First will allow astronomers to study physical processes taking place in quasars, in the nuclei of active galaxies and in the disks of peculiar and normal galaxies with a sensitivity, spatial resolution and spectral resolution unprecedented for this wavelength range. It will also allow them to study major aspects of the evolution of our own Galaxy and of other galaxies, such as the way in which diffuse matter in dark clouds turns into stars and planetary systems, or the manner in which stars of advanced age resupply the interstellar medium with processed matter rich in heavy elements. In addition, First will enable observers to study the early evolution of the Universe, and the origin of galaxies and clusters of galaxies.

Three main instruments are planned in the focal plane:

1. A superheterodyne instrument package with seven different front ends covering the wavelength range of 0.15 mm to 0.65 mm with high spectral resolution.

2. A high-resolution spectrometer operating between 0.1 and 0.2 mm.

3. An imaging multiband photometer with four bands between 0.05 and 1.6 mm.

First is proposed as an *observatory* to be used by Earth-based astronomers in real time, in a way similar to IUE and to the planned operating mode of Space Telescope.

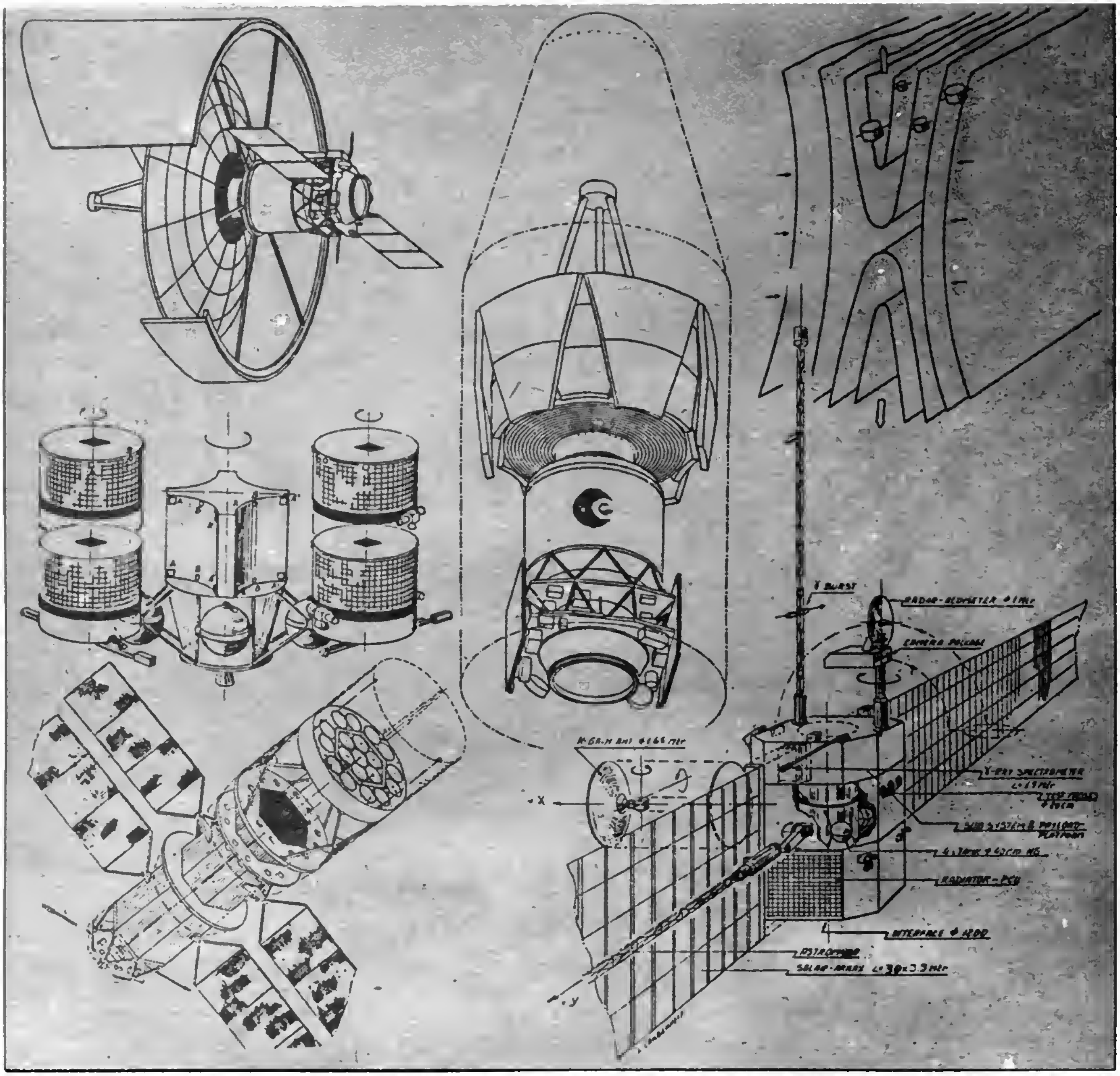
The recent availability in Europe of the various new and advanced technologies required for First makes the project a feasible and challenging enterprise for ESA. ISO's (Infrared Space Observatory) phase A studies resulted in a cryostat system design and a service module suitable for First. An industrial contract on inflatable, space-rigidised, ultralightweight structures points the way for a solar radiation shield. The Ariane IV lifting power of up to 4 tonnes, together with a possible satellite fairing of 86 m^3 ensures a European launch capability.

An infrared view of the Universe from the US/Netherlands/UK IRAS satellite. This is the Andromeda Galaxy (M31), showing areas where stars are probably forming. *NASA*

A related, but much more ambitious project, is presently under study by NASA: the Large Deployable Reflector (LDR). This project, covering the wavelength range of 30 microns to 1 mm uses a 20 m aperture. It requires, however, technologies that do not yet exist; it also needs human assistance for deployment in space.

XMM

The discovery of hundreds of cosmic X-ray sources by the Uhuru, Ariel 5, SAS-3 and HEAO-1 satellites set the stage in the 1970's for an exciting future for X-ray astronomy. The second generation of X-ray missions began with the flight of the Einstein (HEAO-2) satellite. It carried a grazing incidence imaging telescope which provided a 100-fold increase in sensitivity. Einstein expanded the number of known sources by a least an order of magnitude yet probed only about 1 per cent of the sky. A very limited amount of observing time was devoted to astrophysical measurements. For example, spectra for only a few of the brightest sources were studies with the spectrometers. It was not possible to obtain spectral images of extended objects such as nebulae. Nevertheless, Einstein brought about a major advance in the subject and demonstrated in particular that almost all types of normal stars emit X-rays.



Top left: the First telescope deployed in orbit; *top centre,* in launch configuration. *Left centre:* a possible arrangement of the four Cluster satellites before deployment; *top right,* their positioning in the Earth's plasma sheets. *Bottom left,* the XMM X-ray observatory. *Bottom right,* the Agora asteroid probe.
European Space Agency

Exosat, the first ESA X-ray mission, was launched in May 1983. The observing programme emphasises high resolution imaging, broad-band spectroscopic, timing and variability measurements and dispersive grating spectroscopy of the brightest sources. X-80, a spectroscopy and variability mission, would be a logical next step for ESA after Exosat.

A third generation of missions will follow in which the artificial boundary between X-ray astronomy and astrophysics disappears. These satellites will have sensitivity improvements of better than 100 over existing missions. They must be capable of finding and studying in detail either the furthest quasars and active galactic nuclei at the edge of the Universe or detecting the coronal emission from the faintest stars within the Galaxy. Within the NASA programme, the Advanced X-ray Astrophysics Facility (AXAF) is currently under study. The primary application will be X-ray astronomy with emphasis on deep surveys made possible by the high resolution. AXAF will also perform a wide range of science with general purpose instruments. It will, however, be able to make only a limited number of observations at its single focus since the available aperture will be limited by the high costs of polishing the mirror surfaces to the required resolution specifications.

There exists a need for a *multi-purpose* observatory. The high costs and other limitations of the AXAF single focus system argue in favour of an array of telescopes with some compromise in angular resolution but with at least a factor of 10 more collecting area, particularly at high energy.

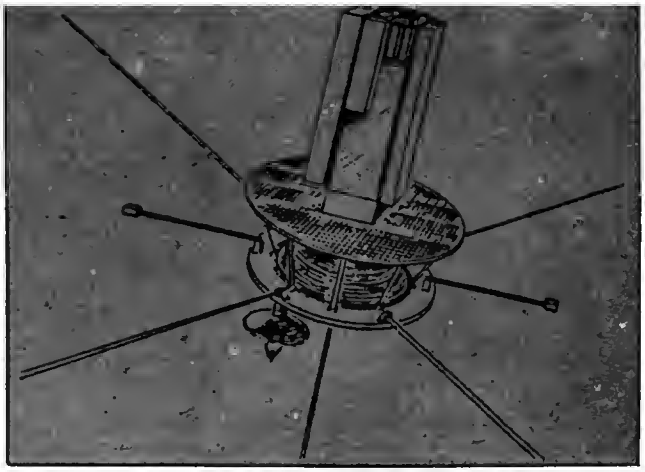
The proposed X-ray Multi-Mirror satellite would carry a cluster of mirrors of about 50 cm diameter to provide two kinds of telescopes. The first array will have good resolution to observe such objects as faint stars in our own and nearby galaxies; the second array will not be as powerful but it will cover a greater range of X-ray energies. It would be used for observing, for example, distant active galactic nuclei and producing temeperature maps of extended objects.

The Solar and Heliospheric Observatory (SOHO) will address basic questions regarding the Sun and its heliosphere. Why does the corona exist? Where is the solar wind, which carries away mass from the Sun, accelerated? What is the structure of the solar interior?

The instruments on SOHO will:

1. Investigate the outer layers of the Sun (the chromosphere, transition region and corona) by powerful spectroscopes;
2. Study the solar wind streams and associated wave phenomena with a set of particle and field instruments;
3. Probe the Sun's interior structure by monitoring the velocity and luminosity oscillations of the solar "surface," i.e. by the methods of 'helioseismology.'

SOHO is a three-axis stabilised satellite which would be placed in a halo orbit around the Lagrangian point L1 at a distance of 1,500,000 km from the Earth. The satellite has a modular design with a payload module dedicated to Sun-pointing instruments and a "housekeeping" module not only carrying spacecraft subsystems but also some solar wind instruments. Direct injection into the transfer orbit to L1 would be performed by an Ariane IV launcher.



SOHO would provide information on solar oscillations.

Agora

During the last 15 years, planetary exploration by automatic probes has drastically expanded our knowledge of the Solar System. Each visit to a new planetary body revealed quite unexpected features, such as the huge volcanoes of Mars and Io or the intricate structure of Saturn's rings. The Voyager mission will visit the outer giants Uranus and Neptune in 1986 and 1989, respectively. By then, all the large planetary bodies will have been explored, with the exception of Pluto. The planned fly-bys of comet Halley in early 1986 will be the first missions dedicated to small Solar System objects. Therefore, by the end of this decade, asteroids will remain the only unexplored family of Solar System objects.

The large majority of asteroids are situated in the main belt, at the transition from the rocky terrestrial planets of the inner Solar System to the giant gaseous planets of the outer Solar System. It is generally considered that the planetary formation process stopped at this intermediary stage due to the proximity of Jupiter. Asteroids would then represent the last remnants of the swarm of planetesimals which formed the terrestrial planets. Due to their small size, they should be made up of very primitvie material, essentially unaltered since the early stages of the Solar System.

Earth-based studies of asteroids have much improved over the last decade. They have revealed a wide variety in sizes (from a few km to 1000 km), shape, spin rate and surface composition. However, by the end of this decade, these techniques will reach their limits as most asteroids of adequate size and brightness will have been observed. Furthermore, asteroids will remain unresolved point sources even with the Space Telescope (excepting Ceres and, marginally, Vesta). A first exploration mission in the early 1990's would therefore be very timely, and should visit at least three asteroids of different size and type, to provide a significant sampling of this diverse family of objects. The example of similarly complex families such as the Jupiter and Saturn systems proves that the potential for discoveries of such a mission is very high.

Two types of missions can be considered: a multiple fly-by mission, already studied by the agency (Asterex), and a multiple encounter mission including at least one rendezvous. The latter makes possible observing periods of several months in low orbit, to be compared with a few minutes during a fly-by. The core payload selected for both rendezvous and fly-bys include a wide angle and a high resolution camera, an infrared spectrometer, and a radar altimeter/radiometer. The performances of these instruments are clearly improved during a rendezvous, but the major scientific advantage of the long acquisition time is the chance to use chemical analysis techniques. A cruise payload has also been included to study the interplanetary medium.

On the technical side, the Agora (Asteroid Gravity, Optical and Radar Analysis) mission is driven primarily by the requirement of achieving multiple rendezvous orbits with preselected Main Belt asteroids, using European hardware as far as possible and an Ariane launcher in the early 1990's. The assessment study has shown that it is possible to achieve a wide variety of missions of 4 to 6 years all meeting the scientific requirements and with sufficient launch windows, provided an ion propulsion system is carried.

Instruments would allow high resolution photography of selected regions of an asteroid, infrared mapping, determination of chemical composition (with a gamma-ray spectrometer) and altitude mapping.

Cluster

The Cluster mission has been designed primarily to study small variations in the Earth's plasma environment and the associated turbulence. Four satellites instrumented to make comprehensive measurements of plasma particles and electromagnetic fields would be placed in a suitable orbit which takes them through key regions of geospace. An eccentric polar orbit with apogee at 20 Earth radii near the equatorial plane can cover these objectives. In order to study the small-scale structures and disentangle position from time variations a minimum of four satellites is required.

The satellite designs are based on standard technology and the great majority of the subsystems can reuse existing hardware design from the past scientific projects (ISEE–B, GEOS, ISPM, Giotto, etc).

For the baseline configuration the main spacecraft mass is 270 kg (40 kg fuel) and requires 140 watts, while each companion spacecraft weighs 217 kg (32 kg fuel) and requires 118 watts of power.

This feature has been prepared from material supplied by the European Space Agency.

MANKIND'S INTERSTELLAR FUTURE

By Dr. Anthony R. Martin

Looking into the future of Mankind over the next century or so is a task fraught with dangers for the unwary. Dr. Martin, editor of the "Interstellar Studies" issues of the Society's Journal, describes an interesting experiment in the prediction of Man's progress into space.

Introduction

In July 1975, the Subcommittee on Space Science and Applications of the United States House of Representatives solicited proposals and held hearings on new ideas for future US space programmes. One of the many proposals that they received was a paper by Robert Forward which concentrated specifically on just one particular aspect of future space programmes: interstellar exploration.

Bob Forward proposed a 50 year programme for interstellar exploration, beginning in 1975 with interstellar mission definition studies, continuing through the 1995-2000 period with the launch of probes to Alpha Centauri, Barnard's Star, Sirius and Lalande 21185, and culminating in the launch of the first manned interstellar exploration expedition in 2025.

Several years later, in 1978, the Project Daedalus Study Group, with which I was heavily involved, presented the results of their five-year investigation into the feasibility of unmanned interstellar probes, concluding that such missions were feasible. However, the timescales for the launch of vehicles to the nearest stars would be set by the requirement for a Solar System-wide culture to be in existence, in order to provide the economic base, the material resources needed, and the long term political stability necessary for supporting a mission lasting of the order of 50 years. The suggested period when this would come about was sometime in the latter part of the 21st Century, and we could not see any means of bringing this time forward by any substantial amount.

Both these widely differing timescales were subjective. They relied upon the personal inclinations and ideas of one or a few people Often this is the only way in which a project timescale can be formulated, at least in the early stages of the project. Then, as knowledge is gained and the problems and barriers to further progress are identified, the timescales become less subjective and more solidly based upon technical and managerial input.

However, with the rapid increase in the technology base of our present society (at least in the developed countries) there has been an increasing awareness for the need to provide timescales which are as realistic as possible from the outset. A large amount of work has therefore gone in to developing methods of technological forecasting for industry and government organisations as an aid in taking planning decisions.

I wondered therefore if it would be feasible to use one of these forecating tools to attempt to arrive at less subjective timescales for certain events relevant to Interstellar Studies. This developed into an experiment involving a group of 15 people interested or active in the topic, and a set of 11 questions. The full results and analysis of the experiment are described in the November 1983 "Interstellar Studies" issue of *JBIS*, but a condensed version is included here.

Second stage separation of a Daedalus-type interstellar probe. (Original 1981 painting by Don Dixon, presented to the BIS by Douglas Arnold of Space Frontiers Ltd.)

The Method Used

One of the methods in common use, and arguably the most successful, is the Delphi method of event forecasting. This is named after the place in ancient Greece famous as the seat of the most important temple and oracle of Apollo. The oracle was consulted not only on private matters, but also on affairs of state and its utterances often changed national policy. It was also consulted whenever a colony was to be sent out — a coincidence that I find pleasing in view of some of the questions asked during the experiment.

In order to predict possible future events, and the timescales for their occurrence, a forecaster must establish the sources of knowlege and expertise, and use this knowledge and the judgements of the experts in such a way that the forecast reflects their many and complex mutual interactions.

The most often used method of achieving this is *via* a series of meetings or conferences, where experts meet to discuss the topics set before them and attempt to achieve a consensus point of view. However, this procedure has many demonstrated shortcomings, particularly in the areas of inadequate representation of relevant fields, deference to authority resulting in a weighting of different points of view, and sociological factors in the group interaction, such as persuasiveness of presentation, reluctance to modify previously expressed views, and the "bandwagon effect."

With these shortcomings in mind, Theodore Gordon and Olaf Helmer, working for the Rand Corporation in the US, developed the Delphi method of using a questionnaire approach in the early 1960's. The inputs for the Delphi technique are still subjective in nature, and the method should be used only where objective data are unobtainable. However, it is for these reasons that the method is most useful for longer term forecasts, and this is precisely the role that the method was being called upon to fulfill in the present experiment.

Delphi is a technique for achieving a structured anonymous interaction between experts using a questionnaire approach with controlled feedback of information designed to eliminate or reduce the shortcomings of the face-to-face meeting. A series of questions or 'event statements' about the future is circulated to experts who are asked to make their individual forecasts. These responses are analysed, resubmitted to the experts who are asked to provide the reasons for their forecasts. Subsequent rounds of the questionnaire provide a vehicle for communication and permit further information to be elicited leading to modification of the original forecasts."

The Experiment

The experiment itself consisted of a four-round Delphi, with the following sequence of events:

Stage 1 Questionnaire distributed to participants, who were asked to give their estimates of the dates by which they were 90 per cent certain that a list of unconnected events will have occurred.

Stage 2 Questionnaire re-circulated, with median date and interquartile range (IQR: the interval containing the middle 50 per cent of responses) added for each event. Participants asked to reconsider their previous answers and revise them if desired. If the new response lies outside the IQR, the participant was asked to state the reason for thinking that the answer should be that much higher, or that much lower, than the majority judgement of the group.

Stage 3 Questionnaire re-circulated, with revised median date and IQR indicated for each event, together with a concise summary of the reasons presented in support of positions outside the IQR. Participants asked to revise their estimate, taking these arguments into account. If the answer is still outside the IQR, then the participant was asked to state why he was unpersuaded by the arguments.

Stage 4 Questionnaire re-circulated, with revised median date and IQR indicated for each event, together with the criticisms of the arguments from Stage 3. Participants were asked to give their final estimates.

It is, of course, possible for the experiment to progress beyond four rounds, but in practise it has been found that any shifts occurring in the forecasts after round four are usually not significant.

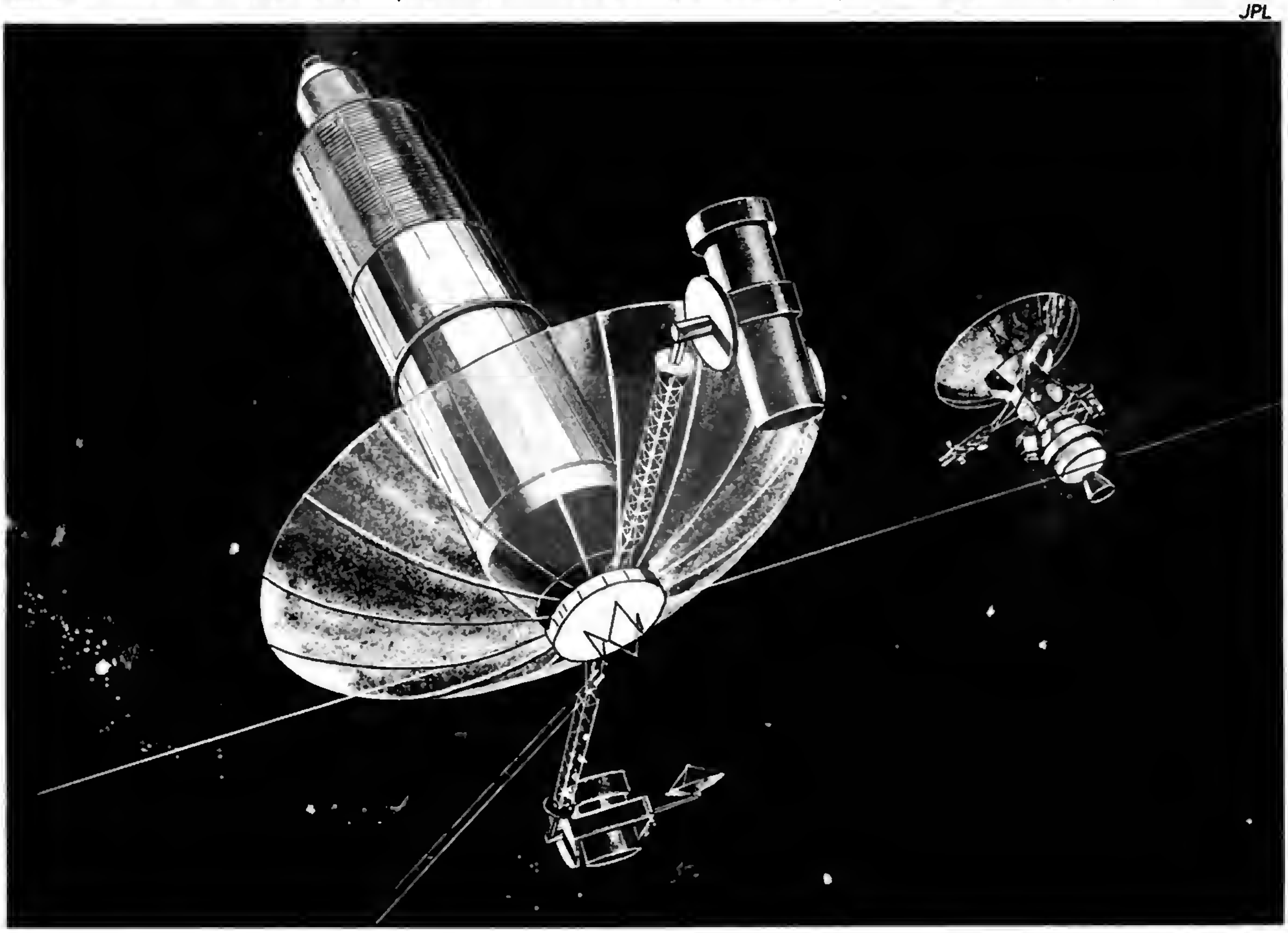
The participants in the Delphi experiment were (and I would like to thank them all for their efforts and co-operation in the course of the work): R.A. Buckland (UK), R.L. Forward (USA), T.J. Grant (UK), S.B. Kramer (USA), A.T. Lawton (UK), I.G. MacKinlay (UK), G.L. Matloff (USA), M.A.G. Michaud (USA), P.M. Molton (USA), J.A. Parfitt (UK), R.C. Parkinson (UK), G.R. Richards (UK), K.J. Rooney (UK), G.M. Webb (UK) and D.P. Whitmire (USA).

In the reporting of the experiment in *JBIS* "Interstellar Studies" opinions and arguments are not identified with any specific participant. The aim of the experiment was to provide an anonymous consensus of opinion. In addition, many times different participants voiced the same points of argument.

The Results

The final questions decided upon for the Delphi experiment were circulated in the form shown below. The

Artist's impression of an interstellar precursor probe, median launch date of 2054 in the Delphi study. Below the main probe is a Pluto orbiter, released as the main craft leaves the Solar System. (See "An Interstellar Precursor Mission" by L.D. Jaffe *et al*, *JBIS*, January 1980, pp.3-26). *JPL*



median dates and the interquartile ranges resulting from the study are also given. Arguments for or against the different dates are detailed in the *JBIS* paper and give some of the flavour of the discussions and variation of opinion present during the study.

1. First manned mission to the Jupiter system.
   Median date: 2029
   IQR: 2024-2037

2. First manned mission to the edge of the Solar System (Neptune/Pluto distance).
   Median date: 2058
   IQR: 2045-2070

3. Large groups (greater than 1,000) living in space (including the Moon).
   Median date: 2024
   IQR: 2020-2030

4. Extensive use of Solar System natural resources, excluding Lunar material.
   Median date: 2040
   IQR: 2030-2050

5. Rapid, reliable transport within the Solar System.
   (The meaning of "rapid" was queried by several participants, and the subsequent definition was "between Concorde and the Cutty Sark")
   Median date: 2040
   IQR: 2030-2050

6. Detection of an extrasolar planet.
   Median date: 1992
   IQR: 1990-1995

7. First unmanned interstellar probe launched from the Solar System.
   Median date:2054
   IQR: 2045-2060

8. First manned interstellar probe launched from the Solar System.
   Median date: 2140
   IQR: 2130-2200

9. Colonisation of an extrasolar planet by a mission launched from the Solar System.
   Median date: 2260
   IQR: 2210-2320

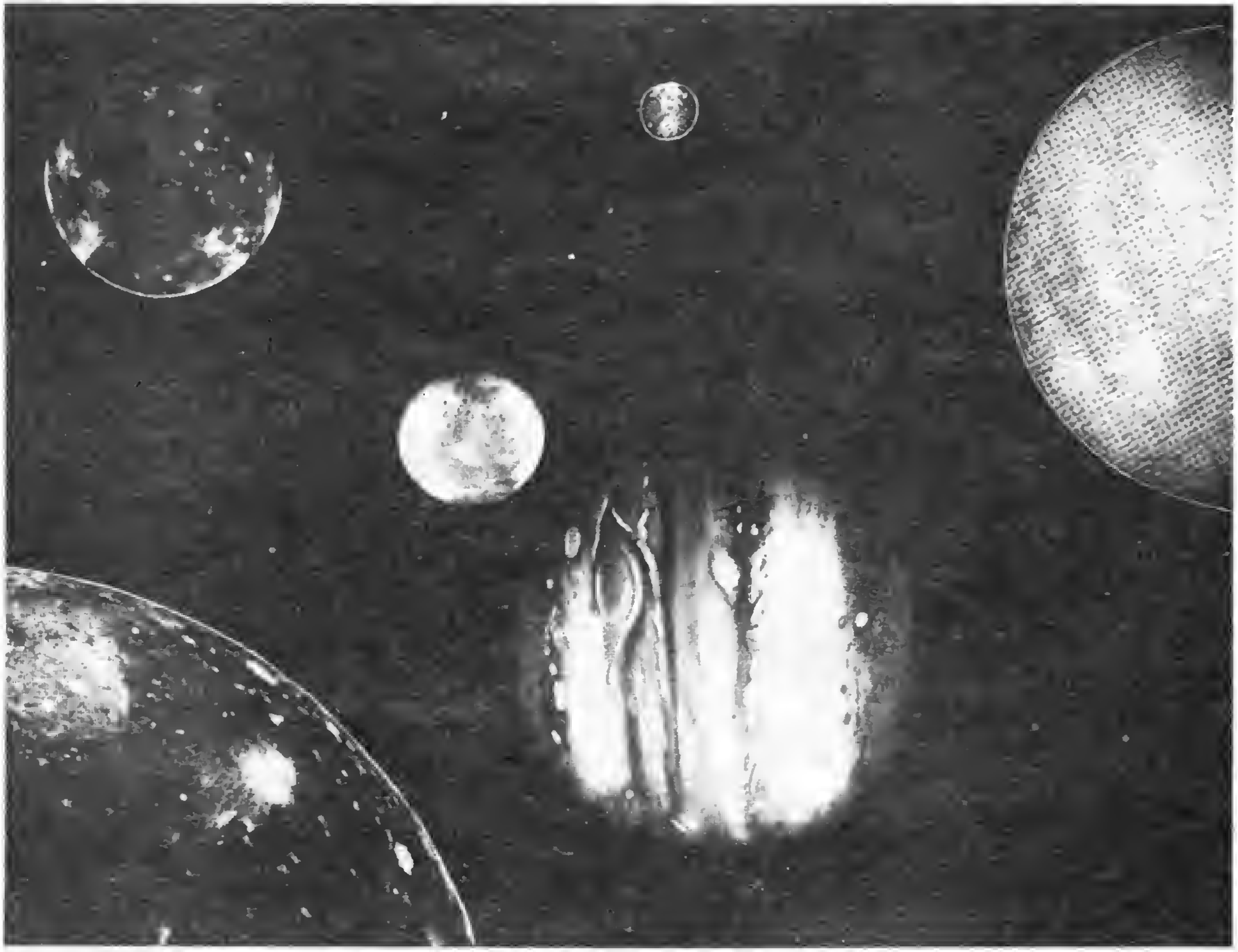
10. Development of artificial intelligence to a level equal to that of a human.
    Median date: 2058
    IQR: 2020-2071
    3 responses of "Never"

11. Contact with extraterrestrial intelligence (not necessarily communication).
    Median date: 2066
    IQR: 2050-2100
    2 responses of "Never"

A Scenario Approach

An interesting study was carried out by the Hudson Institute in the USA in 1977, and took the form of a series of scenario forecasts of space development in the

A target for a manned planetary mission: the Jovian system. The median launch date for such a mission in the Delphi study was 2029 — only 35 years hence. *NASA*



stations at NBC affiliates nationwide, as well as a satellite network management system. The full system will be operational by January 1985, making it the first system to distribute network TV programming over advanced Ku-band satellites.

A TRIO OF SATELLITES

A troiko of new, multipurpose communication satellites are to be marketed by the Hughes Aircraft Company. The satellites, designated the HS 393, HS 394 and HS 399, represent the latest advancements of Hughes' satellite technology into the domestic communications and direct broadcasting arenas. The HS 394 has the added feature of a flat, Sun-tracking solar array, thereby combining the best features from the existing technologies of spin-stabilised satellites and body stabilised satellites.

The wide-body HS 393 domestic communications satellite can accommodate varied requirements, from 16 high-power channels to 48 lower power channels for standard communications needs.

Using features developed on the HS 376 satellites and incorporated into the Intelsat 6 craft, the HS 393 has a folding antenna and two concentric cyclindrical solar panels. Stowed for launch, the satellite is only 3.4 m high. On orbit, with the antenna erected and the solar panel extended, it stands 10 m high.

The 12-transponder HS 399 satellite, which occupies only 7% of a Space Shuttle cargo bay, provides a post-1985 Shuttle launch cost into transfer orbit of under $10 million. A 4 kW satellite, the HS 394 has a wide range of applications, including direct broadcasting, mobile communications and conventional transmission in multiple frequencies.

The satellites mark the 14th to 16th families of communications satellites developed by Hughes, which has built more than two-thirds of the world's current commerical communications satellites.

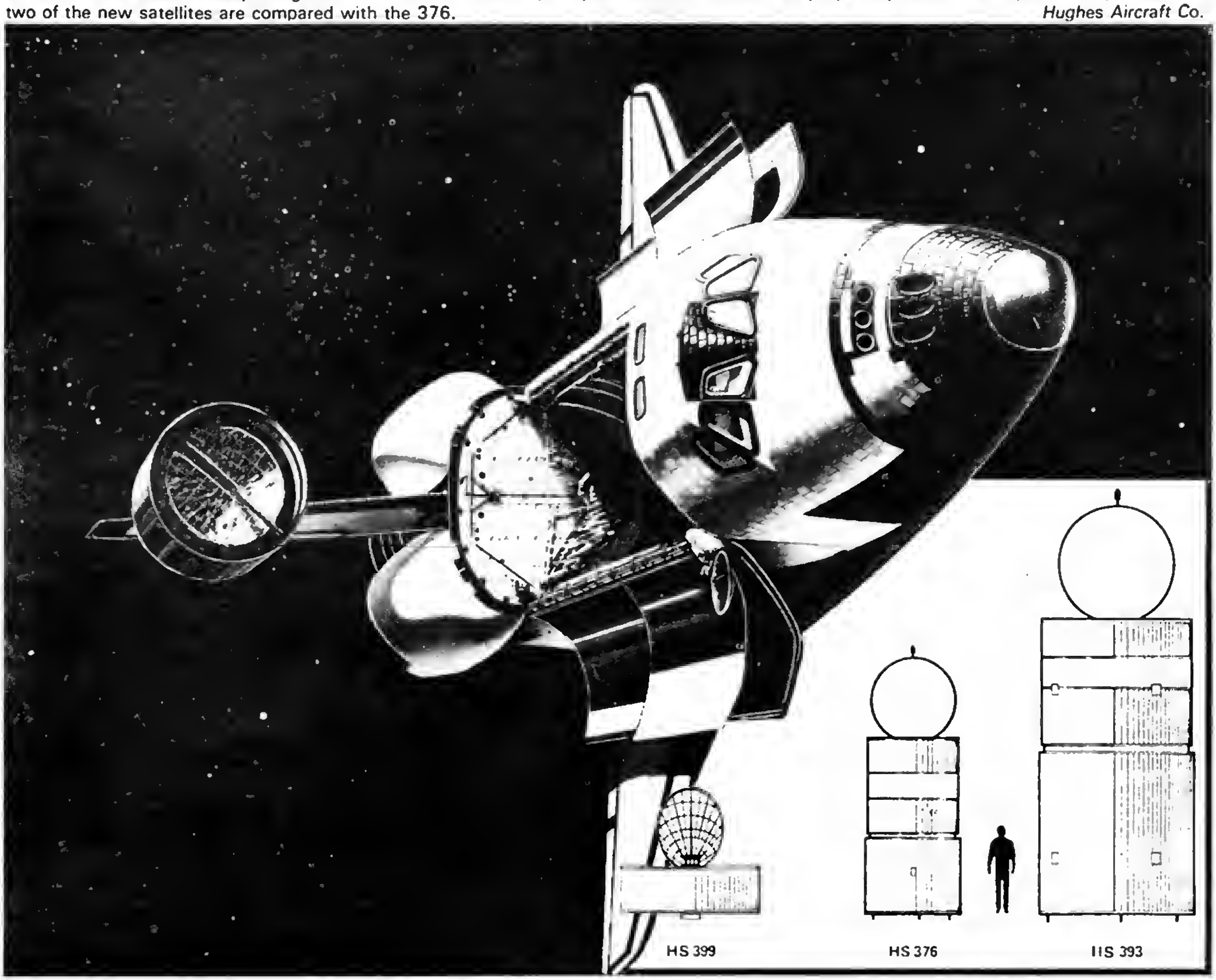
SATELLITE CAPACITY DOUBLED?

The number of channels on a communications satellite could be doubled using a new amplifying system developed at NASA's Lewis Research Center.

The new system, termed a Dynamic Velocity Taper (DVT), is actually a relatively minor technical modification of an existing space amplifier.

Most nations are seeking additional service from communications satellites for voice, picture and data transmissions. But the closest that such satellites can be spaced around the globe at the geostationary orbit level is two degrees; otherwise the signals from one satellite would interfere with an adjacent satellite. Hence the number of satellite positions available is fixed and limited, and by the year 2000 the full quota of slots is expected to be in use. The way out of the jam is to make each satellite able to handle more traffic without affecting the quality of the signals.

An HS 395 satellite is sent spinning on its side from the Shuttle, the present 376 models are deployed top first (see the picture on p.82). *Inset:* two of the new satellites are compared with the 376. *Hughes Aircraft Co.*



CHALLENGER'S RETURN TO SPACE

By John Pfannerstill

The successful STS–6 mission in April 1983 paved the way for the Shuttle programme to continue its packed launch schedule. A two-part report on the STS–7 mission begins below.

Introduction

Space Shuttle Mission 7 was planned as the most ambitious Shuttle flight to date. In addition to providing launch services for two commercial communication satellites, the five-person crew was charged with the responsibility of demonstrating for the first time that a Shuttle Orbiter could manoeuvre precisely in close proximity to a small satellite, capture the satellite with the Orbiter's robot arm, and then place it in the payload bay for return to Earth. There was also a wide range of scientific and technical activities planned for the seven-day flight which would help make Mission 7 one of the busiest of the Shuttle programme so far.

The crew was selected in April 1982. They included: US Navy Captain Robert L. Crippen (Commander), Navy Captain Frederick H. (Rick) Hauck (Pilot), US Air Force Colonel John M. Fabian (Mission Specialist–1) and Dr. Sally K. Ride (Mission Specialist–2). A third Mission Specialist (MS–3), Dr. Norman E. Thagard, was added to the crew in December 1982 to collect medical data on motion sickness in space.

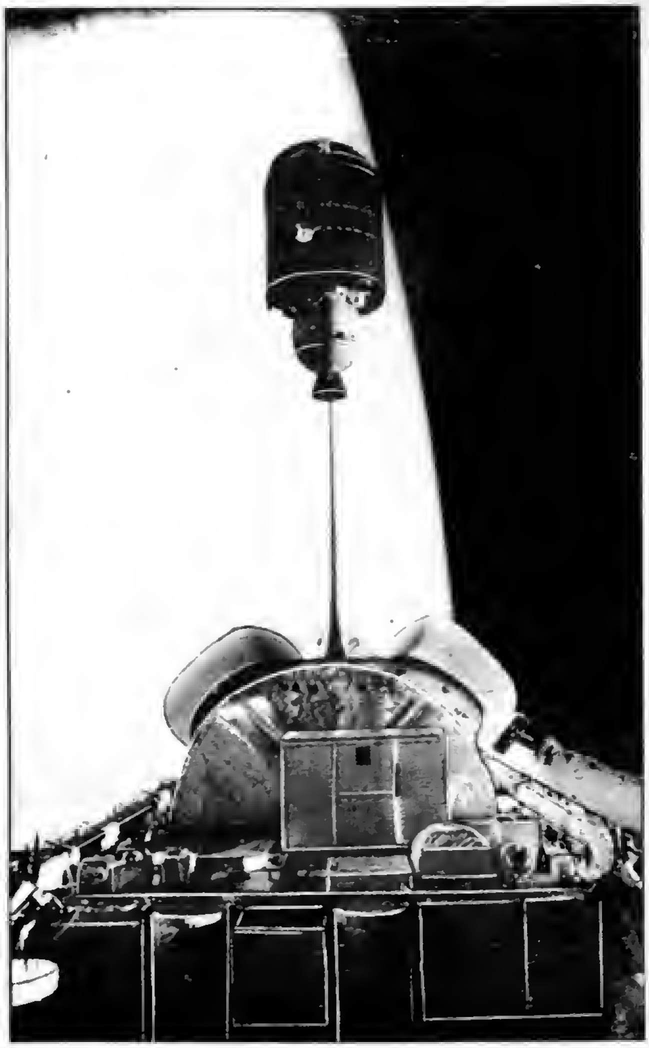
Of the five crew members, only Crippen had flown before in space. He was the pilot on the first Shuttle mission with John Young in April 1981. His STS–7 assignment would make him the first person to fly two Shuttle missions. The four others were all selected for astronaut training in 1978, and were the first representatives of their group of 35 to make space flights.

There was one other important crew-related "first" for STS–7: the first space flight by an American woman astronaut, Sally Ride. Although NASA and Dr. Ride herself tried their best to play down the issue, extensive media attention turned Shuttle Mission 7 into "Sally's Ride" for the general public. It was unfortunate, but reporters' questions dealt more often with whether or not she planned to wear lipstick in space than they did with her flight role. She was, in fact, selected for Mission 7 primarily because of her expertise in operating the Remote Manipulator System (RMS) arm, a skill vitally important in the satellite release and capture activities planned for the flight. Ride was respected and trusted by her four male crew mates, who treated her as an equal. It got to the point, she said, where "Crip even stopped opening doors for me."

Payloads and Experiments

The second operational Shuttle Orbiter, *Challenger*, would be making its second flight on STS–7, having previously logged 5 days 0 hours 23 minutes and 42 seconds of flight time on Shuttle Mission 6 the previous April.

While the STS–7 payload was not the heaviest ever flown on an Orbiter, it certainly was the most diverse. Five different payload elements were loaded into *Challenger's* payload bay, the most ever flown on a Shuttle mission.



Deployment of the Palapa satellite. The pumpkin-shaped object below is the Payload Assist Module.

Starting at the aft end of the bay, they were:

Palapa B–1 communications satellite. Palapa was an HS–376 type satellite manufactured by the Hughes Aircraft Company [1]. Equipped with a Payload Assist Module (PAM–D) solid propellant perigee kick motor, the satellite was to be boosted to geostationary orbit from where it would go to work for its owners, the government of Indonesia. The satellite was designed to improve telephone service to the 155 million people scattered across Indonesia's 13,677 islands. Mission Specialists Ride and Fabian planned to launch the satellite from the payload bay on the second day of the flight.

2. Anik C–2 (Telesat–F) communications satellite. Nearly identical to Palapa, this Canadian satellite was also designed to operate in geostationary orbit, being boosted there by a PAM–D. Once on station, the $24 million satellite was to provide pay television services to Canada and to act as the main on-orbit backup to the Anik C–3 spacecraft launched on Shuttle Mission 5 in November 1982. Assigned a higher priority than Palapa, the Canadian spacecraft would be launched on the first day of the flight, within hours of liftoff.

Office of Space and Terrestrial Applications (OSTA–2) payload. This payload, named for the

forerunner of NASA's Office of Space Science and Applications, was a joint effort between NASA's Marshall Space Flight Center, the German Ministry for Research and Technology and the German Aerospace Research Establishment. Aimed at intensive investigation of materials processing in space, OSTA-2 was divided into two parts, one developed by NASA and the other by the Federal Republic of Germany. Both of the packages were mounted on a new type of payload bay truss called the Mission Peculiar Experiment Support Structure (MPESS).

The US-contributed portion was a box-like desk-sized package called the Material Experiment Assembly (MEA). A self-contained reusable system designed to support many different types of materials processing investigations, for this mission, the MEA carried three. They were:

a. Vapour growth of Alloy-type semiconductor crystals.

b. Liquid phase miscibility gap materials.

c. Containerless processing of glass forming melts.

The West German contribution consisted of three standard Getaway Special (GAS) canisters bolted to the forward-facing side of the MPESS. The canisters were designated MAUS-A, B and C, with "MAUS" an acronym for the German words for "Automatic Materials Processing in Weightlessness." The West German investigations were:

a. Stability of metallic dispersions (which occupied two of the three GAS-MAUS canisters).

b. Solidification front.

All of the OSTA-2 experiments were self-contained, requiring little crew activity beyond flipping the switches to turn the different experiments on and off at designated times.

4. Shuttle Pallet Satellite (SPAS-01). This payload was a reusable satellite designed to operate either berthed inside or flying free outside of the Orbiter's payload bay [2]. On STS-7, both types of operations would be conducted. The SPAS was to be the satellite target for the approach and capture activities mentioned earlier.

On the fifth day of the mission, the crew was to use the RMS to pluck the SPAS out of the payload bay and release it so that they could practise flying in formation. Later, they would use the arm again to capture the satellite and place it back in the bay for return to Earth.

Manufactured by the West German firm Messerschmitt-Bolkow-Blohm (MBB), the 2,278 kg SPAS had seven experiments mounted on its tubular frame. Most of these were designed to operate while the SPAS was berthed in the payload bay, but some could only get adequate data while the satellite was in free flight. The experiments were:

a. Bonn neutral mass spectrometer.

The five Shuttle Mission 7 astronauts pose for a group photo during their seven-day flight. From left, they are, Dr. Norman E. Thagard (Mission Specialst-3), Robert L. Crippen (Commander), Frederick H. Hauck (Pilot), Dr. Sally K. Ride (Mission Specialist-2) and John M. Fabian (Mission Specialist-1). *All photographs NASA*

c. Yaw Earth sensor package.

d. Solar cell calibration equipment.

e. Heat pipes.

f. Modular opto-electronic multispectral scanner.

g. Material wissenschaftliche autonome experiment unter schwerelosigkeit (MAUS-1 and MAUS-2).

5. Getaway Special (GAS) payloads. All told, Mission 7 had seven GAS canisters aboard. This was the largest number ever carried into space on one Orbiter and brought to 12 the total number of GAS payloads flown in the Shuttle programme so far (one canister each was flown on Missions 4 and 5 and three were carried on STS-6). The Mission 7 GAS payloads were:

a. GAS-G002. Jointly sponsored by Kayser Threde, a West German aerospace company and Jugend Forscht, a non-profit German organisation, this 0.14 m^3, \$10,000 canister carried five experiments selected from a nationwide competition among West German high school students. The five experiments were: Crystal Growth Experiment, Nickel Catalyst Experiment, Plant Contamination by Heavy Metals, Biostack Experiment and Microprocessor Payload Control Experiment.

b. GAS-G009. Sponsored by Purdue University, this 0.074 m^3 \$5,000 GAS payload carried three experiments put together by students in the university's School of Science. The experiments were: Space Science Experiment, Biological Science Experiment, Fluid Dynamics Experiment.

c. GAS-G012. Probably the most publicised of the STS-7 GAS payload, this 0.14 m^3 \$10,000 canister was sponsored by the RCA Corporation for the Camden (New Jersey) School System. Students from Camden High School and Wilson High School in the city worked long and hard to develop an experiment aimed at examining the behaviour of a colony of ants in zero-G [3].

d. GAS-G033. Sponsored by movie producer Stephen Spielberg for the California Institute of Technology, this 0.14 m^3, \$10,000 canister carried two experiments aimed at: Examination of space and micro-gravity effects on newly-sprouted radish seeds and; examination of the behaviour of oil and water in micro-gravity.

e. GAS-G088. This 0.14 m^3 \$3,000 canister was sponsored by Edsyn, Inc. and carried nine individual experiments related to soldering and de-soldering in space.

f. GAS-G305. Sponsored by the US Air Force Space Division's Space Test Program and the Naval Research Laboratory, this 0.14 m^3 canister was unique among the

Dr. Thagard conducting just one of the many tests he ran on himself in an effort to discover the cause of Space Adaptation Syndrome.

Mission 7 GAS payloads in that it was the first in the GAS programme to be equipped with an optional motorised door assembly. The door was required because the experiment flown was an unltraviolet spectrometer which was designed to observe emissions from *Challenger*'s payload bay; presumably with a view to assessing possible contamination effects on future Department of Defense Shuttle payloads.

g. GAS-G345. This 0.14 m^3 \$10,000 canister was sponsored by NASA's Goddard Space Flight Center. It was designed to assess the effects of the payload by environment on 12 different types of ultraviolet-sensitive film.

As with all GAS experiments flown on the Shuttle, these would require a minimum of crew time. The astronauts' only job was to turn the experiments on and off at the required time.

In addition to these payloads, *Challeger* also carried in its cargo bay the 15 m long Canadian Remote Manipulator System arm. It was the same arm flown on Shuttle Missions 2, 3 and 4 and, as it had been on those flights, it was mounted along *Challenger*'s port side longeron.

These were not *Challenger's* only payloads however, for two more experiments were mounted inside the crew compartment middeck. These were:

1. Continuous Flow Electrophoresis System

(CFES). The 1.8 m tall 263 kg CFES was making its third flight on the Shuttle, having previously flown on Mission 4 and 6. The CFES uses an electrical field to separate biological materials by the surface electrical charges on individual cells within the material. The McDonnell Douglas Astronautics Company and the Ortho Phamaceuticals Company believed that processing materials in zero-g using the CFES could lead up to the first commercial marketing of space-processed medicines [4].

2. Monodisperse Latex Reactor (MLR). This experiment, too, was a veteran of previous Shuttle flights, having been a passenger on STS-3, STS-4 and STS-6. This materials processing experiment was aimed at zero-g production of perfectly formed latex spheres for various kinds of scientific and technical applications, mainly as size calibration standards. It was hoped that latex spheres as large as 20 microns in size might be formed in space using the MLR [5].

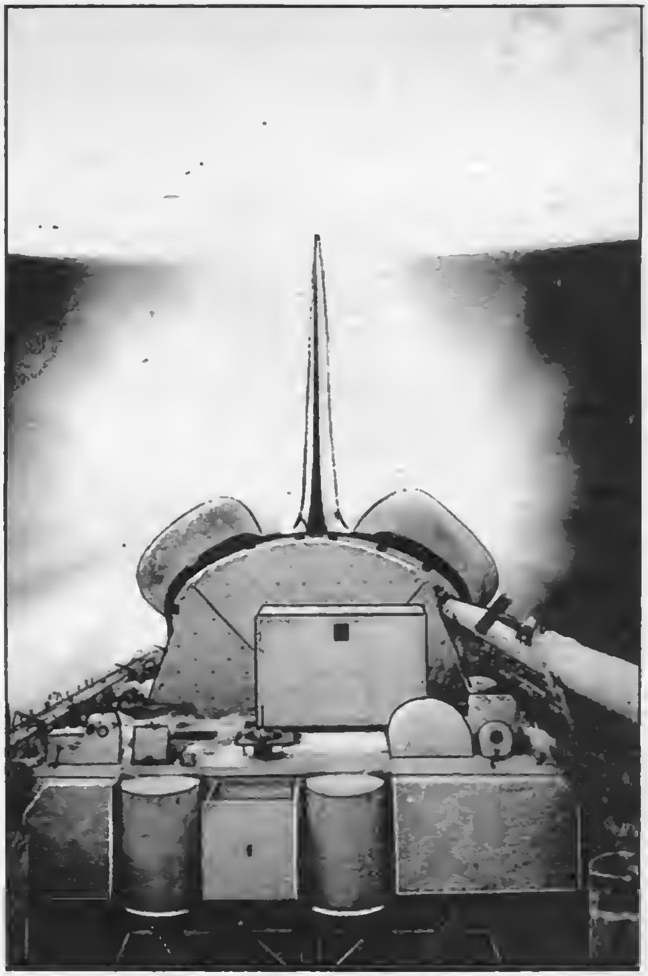
Rounding out the Mission 7 research programme would be the inquiry into motion sickness, or "Space Adaptation Syndrome" as NASA was now calling it. Throughout the Apollo, Skylab and early Shuttle projects, some 40 per cent of all space travellers have become sick upon their first encounter with zero-g. For some mysterious reason, highly trained pilots who could effortlessly fly stomach-turning manoeuvres in jets with no ill effects would suddenly become sick the minute they went into space. There seemed to be no way to predict who would be affected. Gathering additional data on the cause of the problem was why NASA added Dr. Thagard to the STS-7 crew in December 1982. Thagard helped to develop, along with Dr. William Thornton (who would himself be doing motion sickness research on the STS-8 flight) a series of tests and experiments to perform on himself and his crewmates to monitor the changes their individual bodies were going through as a result of adaptation to zero-g. Thagard and Thornton hoped to establish some correlation between these changes and occurrences of nausea. The tests would keep Thagard so busy that he was given no other tasks during the mission. The other four crewmen would do their work independently. In fact, Thagard's activities were not even scheduled into the flight plan so that he would have the freedom to carry out his research in real time as changing events warranted.

Launch Day

The launch and ascent of Shuttle Mission 7 was one of the best ever. *Challenger* with its large brown External Tank (ET) flanked by two white Solid Rocket Boosters (SRBs), vaulted into the sky within 59 milliseconds of its planned 11:33:00 GMT (all times in this report are in GMT unless otherwise noted) launch time on 18 June 1983.

"We're on our way, Flight Seven is airborne!" Crippen exulted as the Shuttle rose through several cloud banks, alternatingly visible and hidden to the thousands of spectators below.

The ascent, particularly the SRB phase, was perfect. In the past, SRB performance had been somewhat erratic, usually producing a low-angle "depressed" trajectory. Although easily compensated for by the Orbiter's three main engines during the later stages of the boost, the depression, if left unchecked, would prove to be costly in terms of weight-lifting capability on later flights. This time, the SRB performance was accurate. Spacecraft velocity was within a very few metres per second of the planned value when the two boosters were cut off shortly after two minutes into the flight. The trajectory plot was also right on target.



A spectacular view of an on-orbit OMS engine burn. Visible in the payload bay are portions of four GAS canisters, the SPAS-01, the top of the OSTA-2 payload (behind the SPAS) and the closed Anik/PAM sunshield (behind the OSTA).

The remainder of the ascent also went extremely well. *Challenger's* main engines were again operated at 104 per cent thrust (as they had been on STS-6) with no strain whatsoever.

Crippen, the only experienced Shuttle crewman in the group, found the ride to be "nice and smooth, maybe even smoother than I remembered on *Columbia.*" As on all flights, the crew noticed small particles coming off the ET. Some of them left streaks on the windshield. Norm Thagard, who was riding by himself down in the middeck, saw quite a bit of material moving past the main hatch window.

Main Engine Cutoff (MECO) occurred right on time at an altitude of 105.6 km and a velocity of 7827 m/s. These were perfect cutoff values.

ET separation was uneventful, and the crew flawlessly performed the OMS-1 and OMS-2 manoeuvres with *Challenger*'s two Orbital Manoeuvering System (OMS) engines to establish themselves in a 297.2 by 296.5 km orbit inclined at 28.5 degrees to the equator. This was very close to the 296.3 km circular path planned.

"Roy, have you ever been to Disneyland?" Ride asked capcom Roy Bridges once the ascent was over.

When Bridges replied, "Affirmative," she told him that the launch "was definitely an 'E-Ticket'." She was referring to a special pass at the famous amusement park which lets visitors on to the most exciting rides.

THE STORY SO FAR

STS-1 *(Columbia)*
John Young (Cdr), Bob Crippen. 12–14 April 1981. Initial test flight of Shuttle. Some thermal tiles lost in launch.

STS-2 *(Columbia)*
Joe Engle (Cdr), Dick Truly. 12–14 November 1981. Second test flight, included use of RMS (manipulator arm). Flight curtailed because of fuel cell problems.

STS-3 *(Columbia)*
Jack Lousma (Cdr), Gordon Fullerton. 22–30 March 1982. Third test flight. Landed in New Mexico.

STS-4 *(Columbia)*
Ken Mattingly (Cdr), Henry Hartsfield. 27 June–4 July 1982. Final test flight.

STS-5 *(Columbia)*
Vance Brand (Cdr), Bob Overmyer (Plt), Joe Allen (MS), Bill Lenoir (MS). 11–16 November 1982. First Shuttle operational flight, carrying SBS-3 and Anik C-3 communications satellites. Planned spacewalk cancelled.

STS–6 *(Challenger)*
Paul Weitz (Cdr), Karel Bobko (Plt), Story Musgrave (MS), Don Peterson (MS). 4–9 April 1983. Launch of TDRS-1 communications satellite. EVA by Musgrave and Peterson.

STS-7 *(Challenger)*
Bob Crippen (Cdr), Fred Hauck (Plt), Sally Ride (MS), John Fabian (MS), Norman Thagard (MS). 18–24 June 1983. Released Anik and Palapa communications satellite. Test SPAS-01 free-flying platform. Intended to make first Kennedy Space Center landing but poor weather forced switch to California.

STS-8 *(Challenger)*
Dick Truly (Cdr), Dan Brandenstein (Plt), Dale Gardner (MS), Guy Bluford (MS), Bill Thornton (MS). 30 August-5 September 1983. First night launch and landing. Released Insat 1B communications satellite. Post-flight analysis revealed solid booster nozzle almost failed.

After getting the payload bay doors opened and the Orbiter all set up for orbital operations, the crew got started on the main order of the day, which was the deployment of the Anik C–2 satellite for Canada.

Preparations for Anik's deployment got underway about eight hours into the mission at 19:30. Fabian and Ride had primary responsibility for the checkout of the satellite and its PAM–D perigee kick motor stage. Their checks were far less time-consuming and complex than those undertaken by the Mission 6 crew in preparation for the deployment of the Tracking and Data Relay Satellite and its Inertial Upper Stage on that mission [6]. This was because the Anik/PAM combination was much simpler with fewer critical systems to check than the TDRS/IUS vehicle.

There were close tolerances, however. For example, the Orbiter's attitude for the deployment had to be very precise, putting a lot of pressure on pilots Crippen and Hauck. This was because the PAM was a spin-stabilised rather than an inertially stabilised vehicle. The Orbiter had to be positioned such that Anik and PAM would be pushed out of the payload bay in exactly the right attitude. Otherwise, the PAM's rocket motor would be aimed in the wrong direction when it fired to put Anik into a geosynchronous transfer orbit.

The Anik deployment countdown shifted into high gear at minus 20 minutes, when Fabian and Ride initiated the start of the Mechanical Sequence on the PAM. This caused a Sunshield over the payload to open, at the same time pulling out two launch retention pins. This permitted the entire 4.45 m, 3344 kg Anik/PAM combination to be spun up to 50 revolutions per minute. It was important that the spin be initiated shortly after the Sunshield opened, for the solar cells covering the exterior of the satellite were so delicate that five minutes of direct sunlight on them without the spacecraft spinning would have caused them to to melt.

Right on time, at 21:01:29, pyrotechnic charges were fired and the Anik/PAM stack sprang out of *Challenger's* payload bay at a separation velocity of 0.85 m/s. Television views of the event, taped on board for later transmission to Mission Control Center-Houston (MCC–H), showed the spinning cylindrical satellite with its spherical propulsion module moving slowly away with the beautiful deep blue Pacific Ocean 296 km below.

"Okay, Houston," Crippen said, "as previously advertised, we really do deliver. Anik was deployed on time."

"This makes the Orbiter three for three on PAM deploys," Ride added, taking into account two similar deployments performed on Mission 5.

The operation was extremely accurate. Flight Director John Cox estimated that the payload was released from the Orbiter within 450 m of the targeted point and within 0.085 degrees of the targeted pointing angle. This is incredible accuracy when one considers that the Orbiter was moving at over 7800 m/s at the time.

As planned, an on-board timer in the PAM commanded its solid propellant rocket motor to fire exactly 45 minutes after it left *Challenger's* payload bay. By this time, the crew had used an OMS burn to back the Orbiter away to a safe 35 km distance. The PAM engine burned the full 85 second duration planned, adding 2568.5 m/s to Anik's velocity and placing the satellite into a perfect geosynchronous transfer orbit of 36,712 by 296 km. Plans called for Anik's own apogee kick motor to fire on 21 June to establish a stationary orbit over the equator at 112 degrees West longitude by 24 June.

With the successful deployment of Anik C–2, the crew had accomplished the first major objective of STS–7. An eight hour sleep period was next on the agenda.

Mision Day 2

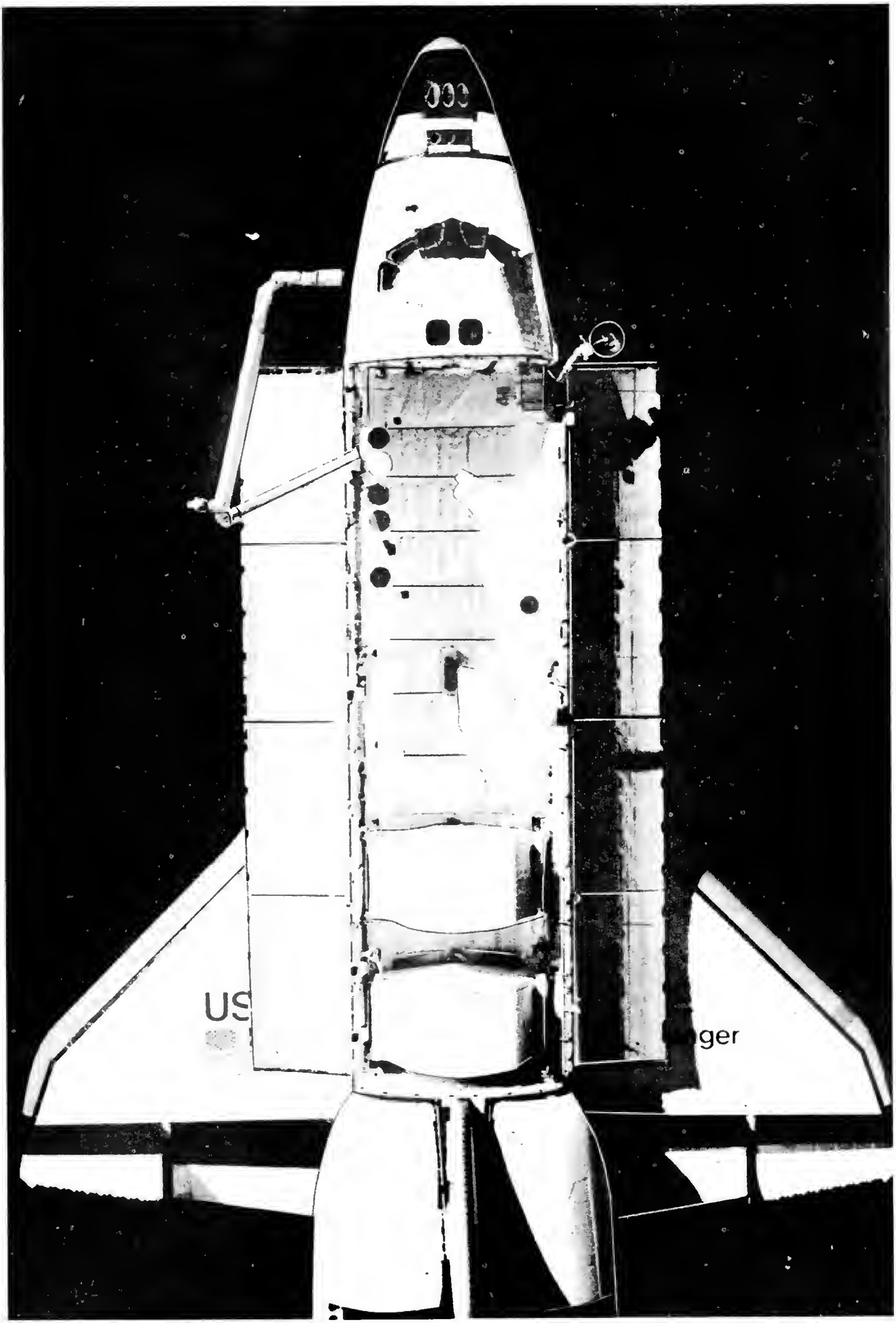
The crew was awakened after their first night in orbit at 08:30 on 19 June. After breakfast and some minor housekeeping jobs, the astronauts got down to work on the preparations for the launch of the second half of their commercial payload, the $37 million Palapa B–1 communications satellite.

Preparations began at about 12:00, some 90 minutes before the satellite's scheduled launch over the Atlantic Ocean on Orbit 18. Being a virtual twin to Anik, Palapa's deployment preparations were almost exactly the same. Once again, Fabian and Ride were in overall charge, with Crippen and Hauck performing attitude control work and Thagard handling the cameras.

As Palapa and its PAM–D upper stage were spun up to 50 rpm, the crew said they could feel a very mild vibration shuddering through the entire Orbiter structure. Then, when the pyrotechnic clamps holding the base of the PAM to the spin table were fired at 13:36:09 releasing the payload into space, the crew reported a very solid "bang."

The deployment once again was perfect. Palapa was ejected with an accuracy comparable to that achieved the

Opposite: A superb overhead view of *Challenger* taken from the SPAS pallet. The free-flying part of the SPAS experiment will be described in the next instalment.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[illegible] Then, just as planned, the PAM solid propellant motor ignited at 14:21:09 to push the Indonesian satellite into a perfect geosynchronous transfer orbit. The firing of Palapa's own apogee motor was scheduled for the following day, which would lead up to its eventual arrival at its operational station over the equator at 108 degrees East longitude.

All of Mission 7's commercial payload was now delivered, and mission specialist John Fabian summed up the crew's feelings: "We're all real pleased obviously to be a part of the fourth successful PAM delivery and we look forward to many more as the years go on."

"Well said, John," capcom astronaut Jon McBride replied, "we feel the same."

After the deployment, the four rookie crewmembers hammed it up for the television cameras wearing special T-shirts they had secretly stowed aboard before launch. The navy blue shirts depicted a rather pathetic-looking Shuttle Orbiter with 35 very busy astronauts crowded into it, onto it and around it in various modes of EVA. Underneath, in bold white letters, it said *TFNG — 'We Deliver.'* The letters TFNG stood for the "Thirty Five New Guys" who were selected for astronaut training in 1978, a group from which Fabian, Hauck, Ride and Thagard were the first representatives to go into space.

Following lunch, the astronauts started on a very busy afternoon of experiment activation and checkout duties. Of prime importance was a checkout of both the RMS arm and the SPAS-01 satellite to ensure that both would be ready for the SPAS free-flight activity planned for Mission Day 5.

At about 17:00, Ride and Fabian activated the SPAS and, for the next 90 minutes, they checked out its various systems and experiments one at a time. There were some initial indications of an anomaly with one of the systems, but further checking by the two mission specialists showed that there actually was no problem at all.

Following the SPAS checkout, Ride and Fabian checked the RMS. The hour-long test involved uncradling the 15 m arm from its stowed position and then checking the operation of its various motors and joint mechanisms one at a time. The hand controllers for the arm in the cockpit were also evaluated as well as the different drive modes available. No payloads were grappled in these tests. The arm was merely flexed to verify its operation.

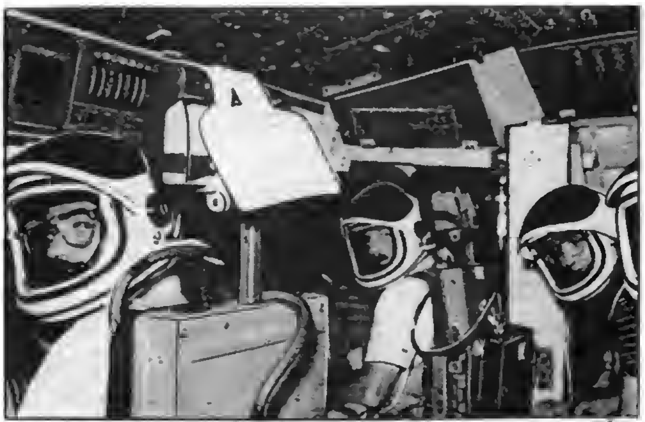
Before an eight-hour sleep period began, the day was rounded out by Ride's activation of the Monodisperse Latex Reactor and several of the OSTA-2 materials processing experiments.

Mission Day 3

Day three (20 June) was to be a busy one, taken up mainly by activity with the SPAS. It was to be the first of two days in which SPAS experiments would be run with the pallet berthed in the payload bay.

But before the SPAS activity, the crew began an important test aimed at aiding future Shuttle missions. At about 09:30 Crippen and Hauck lowered *Challenger's* cabin pressure from its standard 760 mm of Mercury pressure down to 527 mm, where it would be held for approximately 30 hours. The aim was to check out a scheme that would eliminate the need for future EVA crewmembers to undergo a lengthy and uncomfortable 3.5 hour pure oxygen pre-breathing period before every spacewalk. If engineers found that the pressure could be left at the lower level for long periods, the technique could be employed on future missions on which EVA was planned, reducing the pre-breathe period to an hour or less. No EVA was in the STS-7 plan, however.

Crippen and Hauck also test-fired each of the Orbiter's



The crew in simulator training. Thagard sat in the mid-deck area below.

Reaction Control System (RCS) thrusters, and they performed two OMS manoeuvres designed to re-circularise *Challenger's* orbit. The orbit had become elliptical as a result of the separation manoeuvres performed following the launching of Anik and Palapa. After the burns were complete, the Orbiter was flying in a 290.8 km circular path, very close to planned.

Part of the reason for the orbit circularisation was that it would make the data from the SPAS' Modular Opto-Electronic Multispectral Scanner (MOMS) easier to interpret. The MOMS was just one of six SPAS experiments that Ride and Fabian planned to operate in a busy day of work with the pallet satellite.

Fabian asked for and received permission to power up the SPAS early, activating its systems at about 08:55. Then he and Ride turned on the experiments one at a time. The first to be brought up was the Bonn Neutral Mass Spectrometer (BNMS) at 10:35, followed at 12:45 by the Yaw Earth Sensor Package (YESP). Then problems began to crop up. The two astronauts started receiving computer messages indicating that the SPAS Data Handling System (DHS) was being overloaded. All SPAS experiments were shut down to allow MCC-H and the astronauts to study the situation. Initially, the BNMS was thought to be causing the problem, because the only time the overload message ever appeared was when the mass spectrometer was operating. But later study indicated that the alarm was probably nothing more than a false reading, and in the afternoon, Ride and Fabian were permitted to run most of the SPAS experiments normally.

While all this was going on, the third mission specialist, Dr. Thagard, spent most of the day studying the Space Adaptation Syndrome, as he had also done on days one and two. His research into space sickness was complicated by the fact that for the first time in several Shuttle flights, everyone felt fine. So for STS-7 at least, instead of trying to determine why people got sick, Thagard shifted his emphasis to study why Crippen, Hauck, Ride, Fabian and himself did not, which was just as important to know.

Day three did turn up one problem. Cathode Ray Tube (CRT) No. 3 inexplicably failed late in the day. CRT-3 was one of three television screens on *Challenger's* forward cockpit control panel, and was used by the crew to obtain computer information. A similar failure with one of the other CRTs had occurred on the STS-2 flight. On that occasion, mission commander Joe Engle took part of the control panel apart and replaced the faulty screen. This time, MCC-H decided against such a change. CRT-3 was located too close to the handle that would be used to blow off the Orbiter's two emergency exit panels in the cockpit ceiling. The crew would just have to do without the CRT for the remainder of the mission.

To be continued

1984 SUBSCRIPTION FEES

There is good news for UK members: fees for 1984 will remain unchanged from 1983 in spite of rising costs.

Even better news for overseas members who pay in US dollars: the exchange rate means that the 1984 fees are substantially lower than those of 1983.

Direct Debit Scheme

Our old Bankers Order System has now been phased out. Direct Debit slips are available from the Executive Secretary but, as these will not now come into operation until 1985, a separate remittance for 1984 must be made.

Amounts payable for the calendar year January-December 1984 are as follows:

RATES

Members	Sterling	US Dollars[3]
Under the age of 18 years	£16.00	$26.00
Between 18 and 20	£18.00	$30.00
21 years of age and over	£21.00	$36.00
Associate Fellows	£23.00	$40.00
Fellows	£23.00	$40.00

Age Allowance

A reduction of £2.00 ($4.00) is allowed to members of every grade over the age of 65 years on 1 January 1984.

JBIS and *Space Education*

The additional subscription payable for *JBIS*, where required as well as *Spaceflight*, is £20.00 ($34.00). For *Space Education*, it is £4.00 ($7.00).

Methods of Payment

Europe

(a) Please pay in sterling with a cheque which shows a UK address, where it can be paid.

(b) Cheques drawn in sterling on banks in Europe must include £2.00 to defray bank charges and collection costs. Euro-cheques have no charges *only* if the account number is written on the back.

(c) Banks which remit directly to the Society must be told to see that the sum is transmitted *free of deductions*.

(d) Remittances from Europe are best made by GIRO. Our GIRO account number is 53 330 4008.

USA and CANADA

(a) US dollar cheques can be drawn on a Bank which gives an address in the United States or in the UK. US dollar cheques drawn elsewhere need to be increased by $8.00 to cover collection charges.

(b) US dollar notes are accepted.

(c) US or Canadian money orders can only be accepted if *expressed in Sterling*. Internal money orders from these countries i.e. those expressed payable in dollars will be returned as they are not cashable in the UK.

(d) Canadian bank remittances may easily be made in sterling drawn on their UK agents. If payment is made in Canadian dollars the current exchange rate may be used, plus the addition of 8 Canadian dollars to cover exchange and collection charges.

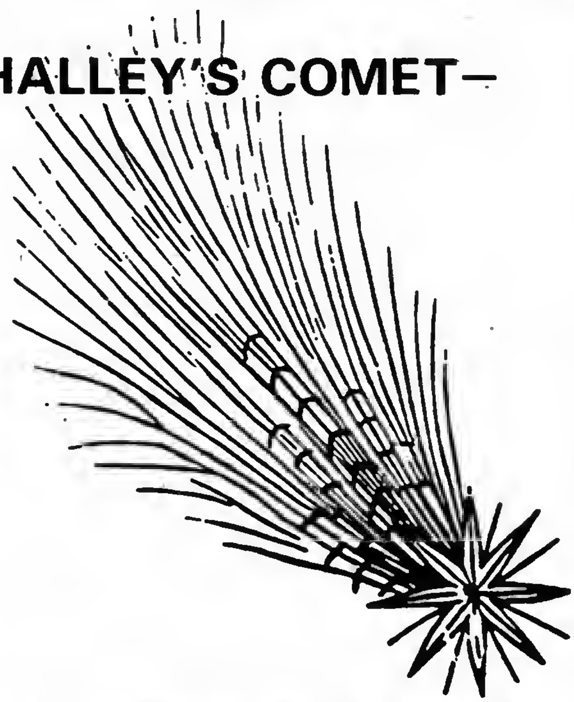
—RENDEZVOUS WITH HALLEY'S COMET—

Owing to the likelihood that Halley's Comet will prove to be a disappointing object when viewed from the Northern Hemisphere, if it can be seen at all, the Society plans to organise a trip to South Africa to view the comet from the Southern Hemisphere. Present indications are that the most favourable time will be the first week in April 1986. The provisional itinerary is: flight from London to Johannesburg, four nights in Johannesburg, three day tour of Kruger National Park, flight to Port Elizabeth, three day tour of the Garden Route from Port Elizabeth to Cape Town, four nights in Cape Town, and return to London *via* Johannesburg. There will be plenty of opportunities for viewing the comet.

The approximate cost at present day prices is £1,000. This includes all air and coach travel, accommodation in first class hotels, plus breakfast and dinner on coach-travelling days.

Forms for provisional registration are now available from the Executive Secretary. Please enclose a stamped addressed envelope.

A deposit of £30 per person is required, fully refundable on written cancellation at any time up to December 1985.



A woodcut illustration of Halley's comet in 684 AD taken from the Nuremberg Chronicles which were first issued in 1493.

Society Educational Tours

Halley's Comet – April 1986 – 14 days duration

ASTRONAUTICS AT BUDAPEST

The 34th. Congress of the International Astronautical Federation was held in Budapest, Hungary on 10–15 October 1983. Len Carter, the Society's Executive Secretary, reports on the proceedings below. We plan to include reports on the Technical Sessions in a later issue.

Introduction

Over 800 participants from 35 countries attended the Congress, the culmination of two years of preparation by the Hungarian Astronautical Society, the Intercosmos Council of the Hungarian Academy of Sciences and other bodies. The IAF currently contains 32 affiliated Societies, with a total membership of 170,000. Press representation from the Western world was sparse but astronauts, cosmonauts and space pioneers were there in force. The Congress venue was one of a group of hotels by the side of the Danube so that journeying between venues took the form of a riverside walk enlivened by the sight of occasional pleasure boats and the cacophony of sound which accompanied the bright yellow trams which emerged from the bowels of the Earth in one direction and vanished into town in the other.

The opening session and most of the technical sessions were held in the Duna Intercontinental Hotel, which coped with everyone easily and readily. Reception and registration was quick and painless, the agonies normally associated with such events being quite minimal. All the usual facilities were immediately to hand e.g. cloakrooms, hotels, tours, currency exchange and photographer, though the latter was something of a mystery insofar as pictures taken of the UK group never subsequently emerged.

About 550 papers were presented spread over 57 technical sessions on the general theme of "Cooperation in Space." Practically all were very well attended though the need to pack so much into less than a week made it necessary to run seven or eight sessions simultaneously almost throughout. New recruits frantically ran from one venue to the other, to catch papers of particular interest: the old hands stayed put, well knowing that papers would not be presented in the order listed anyway and that it would be better, *albeit* far from cheaper, to buy preprints instead and, hopefully, catch appropriate authors on the hop as they went by. Besides these, there were two business sessions and innumerable committee meetings and hurried discussions squeezed in over tea, or lunch, or even during the walk between hotels.

Opening Session

The opening session, in honour of the late Theodore von Karman, began with an address by Professor Martin Summerfield who reminisced about the work of von Karman at JPL and elsewhere but added the following concluding observations:

"In the USA, Robert Goddard has been called the Father of American rocketry, while the name of von Karman has been overlooked. From my personal knowledge of the works of both Goddard and von Karman, I believe that it is more accurate to call Goddard a pioneer and to call von Karman "the Father." The main difference is that a "Father" has offspring who continue his work."

BUDAPEST '83

XXXIV CONGRESS OF THE

INTERNATIONAL ASTRONAUTICAL FEDERATION

Budapest, Hungary 10-15 October 1983

IAF

BUDAPEST '83

"From my personal knowledge, Goddard had no offspring. He transmitted his ideas to no one, partly because he was a solitary, secretive man by nature, and partly because his ideas were mainly unsuccessful. There is not a single American or Western rocket industrial company that can trace its rocket designs to the word of Goddard. On the other hand, many major American and Western industrial companies can trace their designs to the innovative publications of the Caltech Jet Propulsion Laboratory, and many American companies and some Western European laboratories are led today by individuals who were trained by von Karman or by his students who became professors. This distinction between a pioneer and a father has frequently been ignored as, for example, when NASA in the USA named an entire centre for Goddard, who fought with such centres, whereas von Karman worked in many ways to build them. Perhaps some day there will be better recognition of the American Father of rocketry, Theodore von Karman."

This was followed by a Forum which included a number of speeches. Among these was one by Dr. Burt Edelson who pointed out that, over the last 25 years, NASA entered into almost 1,000 international agreements with about 100 countries. These covered the whole spectrum of space projects. Warming to his theme of international cooperation, particularly as costs were thereby reduced, he had some nice words to say about IRAS and Spacelab, the former having exceeded all expectations in its observations of protostars and discovery of comets, including a previously unobserved cometary halo, besides the halo of particles around the star Vega, even though scientists had so far looked at less than 1% of the data! In the case of Spacelab, some 50 industrial firms in ten European countries are participating in the construction of flight hardware. Many new projects were underway, for example:

1. Major Sun-Earth programmes involving six satellites in a programme between NASA and Japan — to study solar-terrestrial physics. Other nations would be invited to join.

2. Planetary exploration mission, which would include comets and asteroids and an atmospheric probe mission to Titan, the largest satellite of Saturn.

3. Studies of the Earth itself i.e. its deep oceans, bioshpere, measurements of its resources, etc.

4. Even more exciting would be the space station. International interest was high. Several countries (regretfully, not including the UK so far) have conducted a number of studies at their own expenses. NASA, itself, was reaching out to all prospective users to identify their requirements.

Business Sessions

The two business sessions, which rolled smoothly through their appointed agenda, were opened by a very nice remark by the IAF President, Robert Chevalier, who congratulated the BIS on its 50th Anniversary and, on behalf of the IAF, sent best wishes for its future, adding his hope that, one day, it will be the host for a future live Congress.

This was received with applause.

Dr. L.R. Shepherd, replying, expressed the view that we would certainly hope to have the Congress between now and our 100th Anniversary and, meanwhile, will think of one inbetween!

Society representatives landed (or were saddled with?) a fair proportion of the activity. Roy Gibson took the strain of the committee for Promotion of Activities and Membership, Ted Mallet the committee on Satellite Communications and Dr. Shepherd on Space Energy and Propulsion. The last is a particularly important area and appears to be perched on top of an edifice of lesser committees all supplying papers and contributing to IAF technical sessions. He also ended up on the IAF Finance Committee and on the Board of Trustees of the International Academy of Astronautics, hence his sudden burst of speed which ferried him into the far distance as he tried to contract others similarly endowed.

Len Carter, fortunately, stayed solely on the Education Committee, this allowed him proper meals and a chance to write this report. Unfortunately, he did not escape completely. He was nominated Vice-Chairman of the Education Committee which then went on to recommend that the Lausanne Congress should feature a Symposium on "Satellites for Education: "Benefits for all Nations" divided into two sessions (to cover systems, software and main results to be expected), together with two further sessions on Student activities.

Members interested in contributing papers to either of these events are invited to contact Len Carter at BIS HQ.

One particularly interesting item was the announcement that the IAF proposed to move to a new address, in the building of the European Space Agency.

After business involving Constitutional changes, there were two changes in membership, both affecting the UK. In came the Institution of Electronics and Radio Engineers and out went the Scottish Association (ASTRA) for non-payment of dues, hopefully on a temporary basis only.

This was followed by Committee appointments, during

The IAF Business Session, with Les Shepherd second from left and Len Carter bringing up the rear.

which the next Congress was fixed for Lausanne, Switzerland, from 8–13 October 1984, with a registration fee approximately the same as for the 1983 Congress. A number of hotel places had been reserved relatively close to the Congress venue at the Palais de Bolieur. It will contain the normal ingredients i.e. an official reception, special programmes for the ladies, a variety of tours to scientific institutions and, undoubtedly, great use would be made of the Lake tours available nearby. Arrangements would be in the hands of the Swiss Association for Space Technology. The theme of the Congress would be "Space Benefits for all Nations." In regard to 1985, the initial offer was for it to be held in Israel but, by the time the Congress concluded, the place was awash with invitations from all parts of the world. To settle matters it was agreed that the IAF Bureau should adjudicate between all these offers over the next few months and, probably, produce recommendations on Congress venues for the next 5 years, including places as far apart as Brazil, Indonesia and China.

The Academy, meanwhile, was doing its own thing — not only by introducing new statutes but also by effecting a change whereby it would henceforth stand on its own feet and no longer be bound to the IAF, though extensive cooperation would continue as before. Currently, the Academy has 566 members but plans are afoot to increase that number. No less that 34 are listed as emanating from the UK though, in all honesty, it is hard to associate some of them with any form of space activity.

Astronauts and Cosmonauts

The Hungarian cosmonaut Bertalan Farkes, who spent eight days aboard the Salyut 6 space station, was present, happily autographing copies of his book. US astronauts Sally Ride, Frederick Hauck and Steven A. Hawley, and the French astronauts Jean-Loup Chretien and Patrick Baudrey were also there for a short time, leaving on Wednesday. One of the Soviet cosmonauts present was Svetlana Savitskaya, the second woman astronaut; she gave an English commentary to a film about her voyage, revealing that she hopes to go on another flight and that there are several more Soviet women cosmonauts queuing up for future flights.

Hungarian/French Presentation on VEGA

The evening of Friday 14th saw a short presentation by K. Szegö of Hungary and J. Runavot of France on the participation of their countries in the USSR-led project VEGA. VEGA consists of two spacecraft to flyby Halley's comet in March 1986 at a distance of 10,000 km. The two spacecraft will be launched in December 1984 and travel *via* Venus in mid-1985, a probe lander being deployed to land on Venus.

Prime scientific questions to be answered on reaching Halley's comet in March 1986 are:

(i) what is the origin of the comets, and

(ii) what are their physical and chemical characteristics?

No comet has ever been studied at close range from a satellite, and this gives a unique opportunity to see if Halley's comet is really a giant snowball or something much more complex.

VEGA will contain several complex experiments for analysing the comets nucleus and surrounding particles. The mission itself should provide useful orbital data on the comet for use by the ESA Giotto spacecraft which will flyby four days later at an altitude of just 500 km.

Bettye Burkhalter explains a vital point while Mitch Sharpe shows a marked lack of attention.

Congress Newspaper

Four issues of the Congress newspaper appeared. They were available at the hotels where most participants stayed and also distributed at the Congress venue proper. For many, it was an opportunity not only to learn about Congress activities but also to keep in touch with UK and foreign news.

A slight hitch occurrred in the last issue when a reference was made to "The Interplanetary Society" — a name by which our own organisation has been known for over 30 years now (for most of that time it had to be listed as such in the telephone directory!) which turned out to be quite unconnected with the BIS. In fact, it didn't relate even to an IAF member-society, which shows the extent of the confusion which can result when a new organisation selects a name closely resembling that of another. If the multiplicity of societies continues then, sooner or later, the IAF will have to think about this problem. In the UK, already, the Companies Acts do not allow one organisation to use a name too closely resembling that of another; the risks of confusion, "passing off" and other complications are too great.

Social

Our feet didn't touch the ground for most of the week when it came to social events, kicking off in fine style to a welcome party given by the Hungarian Trust of Meat Industry and Hungarian Foreign Trade Company on 9 October, the same day of Registration. This was beautifully done. It was held in the beautiful surroundings of the Concert House "Vigado" just a few minutes walk from any of the main hotels. The display was magnificent, with examples of the food given to the Hungarian cosmonaut distributed as souvenirs.

It was followed the next night by a Reception given by Mr. Istvan Sarlos, Deputy Prime Minister, at the Hungarian National Academy, the goodies on that occasion being accompanied by Hungarian music played within the confines of a very fine Art Gallery which had once been a Royal palace.

Invitations to go elsewhere on other nights came thick and fast but, as time wore on, the BIS representatives were perceptively flagging. They did, however, hit the high spots on October 13 i.e. the Society's "official" 50th Anniversary celebration in fine style, being interrupted by momentary pauses to contemplate a large picture nearby showing a bicycle with a giant hexagonal front wheel, the series of bumps which probably resulted being likened to progress of the Society in its early stages.

A reception at the house of the American Ambassador, on the outskirts of Budapest, had to be conducted in pouring rain. So many were present that it proved impossible to circulate in the normal way. I spent the entire

period transfixed, glass in hand, a few feet from astronaut Sally Ride but never got close enough to say 'Hello' nor found space enough to wave at her.

The Ladies programme included a Welcome Party, sightseeing tour by bus, folk dancing, fashion show, horse show and a number of special excursions.

Philatelists Bonanza

A special stamp (and postmark) was issued to mark the Congress and available separately, or with appropriate first-day covers. Trade was so brisk that, before long, other first-day covers were produced to augment sales, as a result of which the Society's collection increased perceptibly!

It is sad to reflect that the history of the British Post Office in this connection is not so spectacular. The prize point we reached, at the 10th IAF Congress at Church House, London in 1959, was the inclusion of a special hand postmark to cancel stamps and with the magic words on it "10th IAF Congress." Even this was not provided by the Post Office for free: it had to be paid for!

Honours and Awards

Dr. Charles Stark Draper (Fellow of the Society), founder of the Instrumentation Laboratory at the Massachusettes Institute of Technology, received the first Theodore von Karman medal while Roy Gibson (Fellow) received the Alan D. Emil award. To both we extend our hearty congratulations.

The Congress also saw the introduction of a new Award in honour of the late Dr. Frank Malina, a Fellow of the BIS until his recent death, presented by members of his family.

Visits

A wide range of visits were offered, some free and some on a pre-payment basis. They ranged from what were virtually holiday jaunts with beer and skittles at the end to one or two serious excursions. To show a good example, I opted for the visit to the Satellite Geodetic Observatory at Penc, but was distressed to find that the rest had gone for the beer and skittles. The Geodetic Observatory, set up in 1976, lay about 40 km from Budapest and undertakes regular satellite observations for geodetic purposes besides research work in geodynamics and astrogeodesy. It undertakes radio Doppler measurements, to within about 1 m accuracy, laser tracking and photographic tracking. The coach journey was most pleasant and the Observatory surroundings particularly attractive.

HOW THE IAF WAS FORMED

In August 1949 several letters arrived from the former Gesellschaft fur Weltraumfahrt containing the suggestion that an international meeting of societies interested in space be held in London, to explore the idea of forming an international organisation. The proposal was to hold this in London in 1951 as this was also the year of the Festival of Britain. The BIS was to defray the cost of the hall and other incidentals.

Unfortunately, one month later, a quarrel broke out between members of the GfW, out of which an independent body, the Nord-West GfW was formed. This was obviously a set-back so the BIS Executive Secretary was aksed to attempt a reconciliation. By that time two other groups had emerged in Germany, one in East Germany and another in the South West.

However, by November 1949 the idea had taken hold and agreement reached for a preliminary meeting to take place in 1950 (wherever the venue might be) for exploratory talks, with the main meeting still being scheduled for 1951 as hitherto.

The informal meeting duly took place in Paris and is still often described as the "first" IAF Congress though it was not until the following year that the real Congress was held. This included business sessions, technical sessions, banquet and excursions — all the ingredients, in fact, which still leaven IAF congresses to this day.

During the business sessions a Constitution was worked out and the IAF duly formed. In this our Society played a major role. In 1959 a second London Congress was held. This time it marked the setting-up of the International Academy of Astronautics and the International Institute of Space Law.

For the first few years of operation the IAF operated from a private address in Switzerland. This was soon found to be unsatisfactory so a committee was set up under the Chairmanship of our Executive Secretary, Len Carter, to try to put things on a more professional basis. With the help mainly of Georges Delval and Jean Poggi, two of our French members, several meetings were arranged in Paris which let to finding a new permanent HQ for the IAF in that City on very favourable terms, thus providing the secure base of operations it so badly needed. The work of Georges Delval and Jean Poggi were crucial to this move and it is only fitting that their efforts be, even if tardily, properly acknowledged.

The BIS featured in outgrowths of the IAF in other ways. The successful work of our Education Committee in fostering a number of books for teachers and students and undertaking a successful spacemobile tour, among other projects, led to the creation of the IAF Education Committee also.

Around this time was an IAF Secretary's Workshop. This had the novel aim of sharing experiences between the Secretaries of IAF member-societies i.e. those most concerned in running space organisations. Experiences and information were swapped over a whole range of administrative and publications chores, with plenty of references to anecdotes and pitfalls. It was most successful but probably suffered from the fault that few IAF Secretaries were prepared to admit that they needed to learn anything. In any event the prospect of advertising further shortcomings was rapidly avoided by making this the one and only meeting of its kind!

IAF CONGRESSES

1950	Paris, France	1969	Mar de Plata, Argentina
1951	London, England	1970	Constance, Germany
1952	Stuttgart, Germany	1971	Brussels, Belgium
1953	Zurich, Switzerland	1972	Vienna, Austria
1954	Innsbruck, Austria	1973	Baku, USSR
1955	Copenhagen, Denmark	1974	The Hague, Holland
1956	Rome, Italy	1975	Lisbon, Portugal
1957	Barcelona, Spain	1976	Anaheim, USA
1958	Amsterdam, Holland	1977	Prague, Czechoslovakia
1959	London, England	1978	Dubrovnik, Yugoslavia
1960	Stockholm, Sweden	1979	Munich, Germany
1961	Washington, DC, USA	1980	Tokyo, Japan
1962	Varna, Bulgaria	1981	Rome, Italy
1963	Paris, France	1982	Paris, France
1964	Warsaw, Poland	1983	Budapest, Hungary
1965	Athens, Greece	1984	Lausanne, Switzerland
1966	Madrid, Spain		
1967	Belgrade, Yugoslavia		
1968	New York, USA		

SATELLITE DIGEST-170

Robert D. Christy

Continued from the January issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

CHINA 13 1983-86A, 14288

Launched: 0600, 19 Aug 1983 from Shuang Cheng Tse by Long March 2.
Spacecraft data: Not available.
Mission: Satellite development, including recovery techniques.
Orbit: 173x382 km, 90.05 min, 63.31 deg.

COSMOS 1493 1983-87A, 14299

Launched: 1100, 23 Aug 1983 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical supplementary payload at the forward end. Length about 6 m, diameter (max) 2.4 m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 360x414 km, 92.30 min, 72.86 deg.

RADUGA 13 1983-88A, 14307

Launched: 2005, 25 Aug 1983 from Tyuratam by D-1-E.
Spacecraft data: Cylinder with a pair of solar panels and an aerial array at one end. Length 5 m and diameter 2 m, mass in geosynchronous orbit about 2000 kg.
Mission: To provide round-the-clock radio, telegrpahic and TV communications within the Soviet Union.
Orbit: Initially a low parking orbit at 51.6 deg inclination and then via a geosynchronous transfer orbit at 47 deg prior to injection into a drift orbit, followed by eventual stabilisation above the equator.

STS 8 1983-89A, 14312

Launched: 0632*, 30 Aug 1983 from the Kennedy Space Center.
Spacecraft data: Delta winged, recoverable spacecraft *Challenger*. Length 37 m, span 24 m and mass (excluding cargo & experiments) around 69 tonnes.
Mission: Third flight of Shuttle Orbiter *Challenger* with crew of Truly, Brandenstein, Thornton, Bluford and Gardner. As well as a scientific and technical payload, the crew launched an Indian satellite to geosynchronous orbit. *Challenger* landed at 0741, 5 Sep 1983.
Orbit: 294x301 km, 90.31 min, 28.46 deg.

INSAT 1B 1983-89B, 14318

Launched: 0749*, 31 Aug 1983 from the payload bay of *Challenger*.
Mission: To provide communications and meteorological services to India. Insat 1B replaces Insat 1A which failed soon after launch in April 1982.
Spacecraft data: Box-shaped body with a single solar panel and a balancing 'sail', dimensions 1.55x1.42x2.18 m and mass 1152 kg fully fuelled.

The Intelsat 5 F-7 and F-8 communications satellites undergo pre-launch preparations at Kourou in French Guiana. F-7 was successfully launched by Ariane L7 on 19 October 1983.
Intelsat

Orbit: Initially as *Challenger* but then moved to a geosynchronous transfer orbit, followed by several motor firings to achieve drift orbit and final stabilisation above 74 deg east longitude.

MOLNIYA-3(21) 1983-90A, 14313

Launched: 2250, 30 Aug 1983 from Plesetsk by A-2-e.
Spacecraft data: Cylindrical body housing instrumentation and the payload is surmounted by a conical motor section. Power is provided by a 'windmill' of six solar panels. Length is about 4 m, diameter 1.6 m and mass around 2000 kg.
Mission: Transmit telephone and TV signals through the 'Orbita' system in the USSR and abroad.
Orbit: Initially 430x40809 km, 735.73 min, 62.89 deg, later adjusted by lowering apogee to give a 718 min period to ensure daily ground track repeats.

COSMOS 1494 1983-91A, 14316

Launched: 0630, 31 Aug 1983 from Kapustin Yar by C-1.
Spacecraft data: Possibly small, standard ellipsoid-shaped satellite, length about 2 m, diameter about 1.5 m and mass around 500-700 kg.
Mission: Not available.
Orbit: 345x550 km, 93.39 min, 50.68 deg.

COSMOS 1495 1983-92A, 14320

Launched: 1020, 3 Sept 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1493.
Mission: Photographic reconnaisance all or part of the payload was an Earth resources package. Recovered after 13 days.
Orbit: 215x236 km, 89.04 min, 82.32 deg.

COSMOS 1496 1983-93A, 14326

Launched: 1330, 7 Sep 1983 from Plesetsk by A-2.
Spacecraft data: Possibly similar to Cosmos 1493.
Mission: Military photo-reconnaissance, recovered or reentered after 42d.
Orbit: 170x341 km, 89.62 min, 67.18 deg. manoeuvrable.

RCA SATCOM 7 1983-94A, 14328

Launched: 2252*, 8 Sep 1983 from Eastern Space & Missile Center.
Spacecraft data: Box-shaped structure, approx 1.5 m each side, mass approx 600 kg (unfuelled).
Mission: Communications satellite.
Orbit: Geosynchronous.

COSMOS 1497 1983-95A, 14330

Launched: 1100, 9 Sep 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1493.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 357x416 km, 92.30 min, 72.85 kg.

COSMOS 1498 1983-96A, 14334

Launched: 1030, 14 Sep 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1493.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package. Recovered after 14 days.
Oribt: 261x275 km, 89.89 min, 82.31 deg.

COSMOS 1499 1983-97A, 14339

Launched: 1115, 17 Sep 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1493.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 357x416 km, 92.30 min, 72.85 deg.

UPDATE:

The three satellites of the 1981-93 launch should be named China 9, China 10 and China 11 respectively. 1982-90A should be named China 12.

Project Space Station

B. O'Leary, Stackpole Books, 159pp, 1983, $12.95.

With the Shuttle and Spacelab as realities, NASA has now set its sights on a new target: a permanent, manned space station.

This book explores current official thinking on the hows, whys and wherefors of a space station project which, by the 1990's, should see a station based on small modules. The uses of a space station have been postulated throughout astronautics for many decades e.g. as a launch base for satellites, fuel base, laboratory, test-bed for new technologies and the stepping off point for deep-space flight. Current thoughts on some of these near-future applications stun the imagination, with weightless factories revolutionising computer technology and pharmeceutical production, lunar and asteroid resources revamping power and structural systems, raw materials in other worlds to replenish the Earth's supplies and, perhaps in time, thousands of people will have the choice of living either on Earth or in a space settlement.

Inherent problems, however, may make the path a thorny one, particularly with the development of laser weapons and the possibility that similar, highly-specialised weapons might set the stage for an all out war in space.

Overall, however, the author concludes that space stations will become a new resource and, looking beyond the year 2000, will provide the stepping stones to new worlds.

Battle for Space

Curtis Peebles, Blandford Press, 1983, 192pp, £9.95.

The author will be familiar to many BIS members as a regular contributor to *Spaceflight*. In this well-illustrated, clearly-presented book, Mr. Peebles sets out to describe the military battle underway for predominance in space — photoreconnaissance, electronic intelligence, ocean surveillance, early warning, laser and particle weaponry.

In a clear, concise text he takes us through the history of military space activities and up to the present day, including such projects as the anti-satellite weapons to be carried by the F-15 aircraft. Chapter headings are: Introducing the Battle for Space, Military Space Systems, The Nuclear Factor, The Origins of Anti-Satellites, The Anti-Satellite Race, Lasers and Particle Beam Weapons.

The book is a must for all space enthusiasts — the military presence in space is something we cannot ignore.

The Atlas of the Solar System

P. Moore, *et al.* Mitchell Beazley, 464pp, 1983, £19.95.

This volume brings together up-to-date information on all aspects of the Solar System at a time when a pause to review the avalanche of new information produced over the past few decades is most timely. It includes more than 700 black and white photographs, at least 150 more in colour, together with some 500 diagrams. The end result is a beautiful volume which practically everyone interested in astronomy would be glad to have.

The atlas adopts an orthodox approach i.e. beginning with the Sun and moving outwards into the Solar System, with concluding sections on the history of astronomy, observations by space probe and amateur alike, a glossary, etc. Each section has been divided into various major areas, e.g. that for the Sun devotes first a couple of pages to detail its main characteristics, followed by short (mainly two page) sections on sunspots, flares, occulations etc. and similarly with Mercury, Venus and the others which follow. The text is in digest form but easily readable and, together with its extensive use of illustrations, presents a substantial body of information.

Space 2000: Selection of Papers from the 33rd IAF Congress

Ed. L.G. Napolitano, American Institute of Aeronautics & Astronautics, 709pp, 1983, $50.

This volume presents a selection of papers delivered at the 33rd IAF Congress held in Paris in 1982, beginning with an invited paper by Yash Pal, Secretary-General of the UNISPACE '82 Conference, on the theme of "Towards Unispace '82 and Beyond." This theme was developed throughout the Congress in a number of symposia, technical sessions, colloquia and current event sessions.

There were eight symposia devoted to transportation systems, five on space platforms and four on communications satellites, among a host of topics developed. Also included were three special symposia *viz* on space economics and benefits; space safety and rescue and the history of astronautics.

For current events, sessions were devoted to the French-Soviet manned flight, Space Shuttle and Ariane, the Salyut-Soyuz programme and the US Landsat and French Spot programme. Other events which took place included a student conference and space law colloquium.

More than 300 papers were delivered at the Congress, some of which have been selected for publication in *Acta Astronautica* and in the present volume. Further papers have also appeared in the journals of IAF member-societies or similar international magazines.

Thirty-nine papers are included in the present volume, covering most of the space spectrum. Many of our old friends are there e.g. the Japanese project to explore Halley's Comet, the Galileo mission to Jupiter, ISPM, etc. Also included are two prize-winning student papers, one on a multi-use space platform and the other on a solar sail concept study.

The text has been produced from original copy submitted by authors so there is a wide variation in presentation but it is clear and easy to read, with a reduction in cost more than compensating for the loss of consistency.

Data Networks with Satellites

(eds.) Joachim Jajus and Otto Spaniol, Springer-Verlag, 251pp, 1983, $15.10.

This volume contains the papers presented at a working conference held in 1982, hosted by the DfVLR and with the aim of bringing together experts involved in developing satellite communications and potential users. Seventeen papers are listed, together with summaries of the more interesting discussions. Major sections include network access, computer communications *via* satellites, applications and services.

The opening paper, by far the longest in the volume, sets out significant issues involved in the design of a satellite data communications system. The discussion is limited to digital techniques but it does include consideration of both digital voice and video as well, with services separated into the categories of fixed, mobile, and transportable — as determined by terrestrial terminal requirements. This is important because different categories place significantly different constraints on a satellite network and provide an important framework within which to judge the efficiency or effectiveness of overall designs.

An interesting contribution describes how, in 1980, invited European newspaper publishers met in London to discuss the possibility of the test transmission of whole newspaper pages from one publishing centre to another, using OTS. In reality it didn't prove to be as easy as it seemed. First was the matter of legal regulations, or their absence, secondly were the problems about the scale of charges and, thirdly, non-cooperation from postal authorities who feared that customers might desert the

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Most of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

telephone network and use satellites instead.

Eventually, in spite of everything, the *Financial Times* obtained a permit for eight days of test transmissions. Tests between London and Frankfurt were carried out late in 1981, using borrowed antennae. These confirmed that transmission was four times faster than by cable and that the quality of the transmitted pages was excellent.

A second paper in this section deals with specialised satellite systems for Europe, an end both necessary and desirable and which, hopefully, will one day come to pass.

Annual Review of Astronomy and Astrophysics – Vol. 21
Ed. G. Burbidge *et al*, Annual Reviews Inc., 482pp, 1983, $47.

Thirteen contributions appear in this volume. Most are concerned with stellar astronomy, the sole contribution concerned with the Solar System dealing with variations in solar luminosity. The two major contributions are concerned with the last stages of evolution of low and intermediate-mass stars and the existence of superclusters, respectively.

Low-mass stars are those which develop an electron-degenerate helium core immediately after the main sequence phase. They thus approach, in the evolutionary track, the first branch for red giants.

In the case of superclusters, the first point is that the distribution of galaxies is "clumpy," ranging from binaries, triples and multiples, up to groups which contain between a few and a hundred galaxies. Thereafter, there are rich clusters with thousands of members and with diameters of the order of 10 Mpc. These lie at the end of the scale of the more or less regular structures in the Universe. There is, also, another type of galaxy conglomeration, with diameters between one and ten times those of the large clusters but with much smaller densities. They are usually irregular and with no central concentration.

The problem is that, although superclusters undoubtedly exist, their boundaries are very ill-defined so it is impossible to tell where one ends and another begins.

Another particularly interesting contribution is that on astrometry, now in the midst of an unparalleled revolution. The author suggests that, within the next few years, measuring parallaxes with an accuracy of ± 0.001 arcsec will become a matter of routine and, in special cases, accuracies of twice that or even better will be possible. Definitive orbits of double stars will prove possible and, with a galactic distance scale based on distances to the Hyades and Pleiades accurate to 1%, it will prove possible to study the dynamical structure of our Galaxy with confidence.

Much of this will depend on the ESA astrometric satellite Hipparcos, which will determine the parallaxes, proper motions and positions of about 100,000 stars down to the 11th magnitude. NASA's Space Telescope, due for launch in 1986, will also contribute much to this work though its principal astrometric uses are likely to be parallax determination and perturbation studies of very faint stars and proper-motion studies of compact clusters.

Activity in Red-Dwarf Stars
Eds. P.B. Byrne and M. Rodono, D. Reidel Publishing Co., 669pp, 1983, $85.

Low-mass stars in the main sequence have long been a source of fascination. They provide the dominant component of the luminous mass of our Galaxy and, very likely, the source of the diffused soft X-ray background. As such, they are prime targets for comparisons between solar and stellar activity. This has made great strides during the last decade, stimulated particularly by the opening of new parts of the electromagnetic spectrum through satellite-borne instrumentation.

The Sun provides many comparitive features e.g. spots, flares, plages, transition regions and corona. Solar-type phenomena in other stars have been postulated since the beginning of this century but actual progress is dependant on long-term observational and theoretical programmes.

Satellite-borne instruments have made possible the study of the outermost layers of stellar atmospheres in previously unexplored spectral bands. A major achievement has been the concept that the stellar atmosphere is not a passive intermediary between the interior and space i.e. rather like a skin surrounding each star, but are really active structures which exhibit a whole panoply of spectacular phenomena.

Be Stars
Eds. M. Jaschek & H.-G. Groth, D. Reidel Publishing Co., 523pp, 1986, $56.50.

Be stars are, generally, non-super giant stars which show emission in one Balmer line at least once. The growth of knowledge concerning these stars has been considerable over the past ten years, thus leading to the present volume which presents the most recent information within the framework of an observational approach.

Sections are included on photometry, polarization, spectroscopy, infrared, rotation and binarity, X-ray, UV and mass loss and atmospheric models, each being opened by a summary paper. A special feature is a section devoted to bibliographic problems and observing campaigns.

Diffuse Matter in Galaxies
Eds. J. Audouze (et *al)*, D. Reidel Publishing Co., 262pp, 1983, £39.50.

The study of the interstellar medium is one of the most recently-developed topics in astrophysics. Understanding the physical status of the medium requires observation at every possible wavelength, particularly in radio and in ranges available only from space, such as infrared, X and gamma rays. Recent measurements show that the interstellar gas is made from relatively cold and dense clouds which are surrounded by a relatively hot tenuous medium.

This present volume, based on a meeting in 1982, is devoted to the analysis of the second aspect i.e. the hot and tenuous component. Eleven of the lectures are now embraced in this book. They review such aspects as methods of observation and determination of physical properties, for the evolution of this diffuse medium must clearly play a major role in galactic evolution.

Readers will find the description of the interplay between the interstellar medium and stellar winds and supernovae particularly interesting.

Solar and Stellar Magnetic Fields: Origins and Coronal Effects
Ed. J.O. Stenflo, D. Reidel Publishing Co., 564pp, 1983, $67.50.

Over the past decade, there has been a gradual convergence of solar and stellar physics, with the unifying role being played by magnetic fields. Recent ground-based observations have provided much valuable material on the empirical connections between stellar rotation — magnetic activity — cycle/age, thus providing a new testing ground for theories about generations of magentic fields in stellar interiors. Cyclic behaviour similar to the Sun is apparently quite common, for many stars also show regular fluctuations.

On the theoretical side, unified theories have emerged which seek to explain the origin of *all* cosmic magnetic fields e.g. including those of the Earth, Sun and Galaxy. The solar magnetic cycle has been a well-used testing ground for these theories though too many unknown parameters still supervene.

Observations with the Einstein and IUE satellites proved particularly important, leading to new insights into the role of magentic fields in the structure and energy balance of stellar atmospheres. This made it all the more timely to bring together observers and theoreticians in a major interdisciplinary symposium, to try to obtain a more unified view of various aspects of solar and stellar physics.

SPACE SOUVENIRS

The Society produces a wide and varied range of items for sale, all of high quality. Why not buy a T-shirt or badge for yourself, or treat a friend? Remember, you'll not only support our work but also provide valuable advertising for the Society.

Binders

The ideal way of keeping your magazines in perfect condition. *Spaceflight* binders carry *BLUE* covers, those for *JBIS* are *GREEN*. Gold lettering on the spine identifies the magazine, volume number and year. Cost: £5 ($10 abroad) each. Note: *JBIS* binders fit post-1976 volumes.

T-SHIRTS

Our Society T-shirt has always been a popular item. Two styles are available: white with a large navy blue BIS logo on the chest, or navy blue with a pale blue logo.

The blue T-shirt in chest sizes 32-34, 34–36, 38–40 & 42–44 inches. The white T-shirt is available in the two smaller sizes only. Cost is £3.50 in the UK or £4 ($8) abroad. Please be sure to specify the style, colour and size when ordering.

50th ANNIVERSARY TIES

We have always produced a high-quality navy blue tie that will grace any space buff's apparel. Now, to mark our 50th year, we are re-introducing the former blue tie showing a rocket against a star background.

For our 50th Anniversary year, the rockets will appear in GOLD to show, unmistakeably, that we have every reason to be proud of our achievements.

As these ties will be unique souvenirs only a limited number will be produced, so please place your order now to avoid disappointment. Next year, the ties will revert to the silver once more. The cost is £6 UK or £6.50 ($13) abroad per tie.

SPACE TANKARDS

In response to many demands, glass tankards of the type presented to the Speakers at the Society's Space '82 conference are being produced to mark **Space '84,** to be held in Brighton, 16–18 November 1984. Orders (UK only – sorry but we can't run the risk of damage in sending abroad) should be *sent direct* (not to the Society) to:

Western Glass International, Western Glass Works Ltd., Armstrong Rd., Daneshill East, Basingstoke, Hants RG24 0QE.

The cost is £10 (postage & packaging free). All profits will be donated to the Society so this is your chance to obtain a unique souvenir and to benefit the Society at the same time.

VISION OF SPACE

Your chance to own a superb 40-slide collection of the best works of Space Art pioneer Chesley Bonestell, a Fellow of the Society. "Chesley Bonestell's pictures," Wernher von Braun once said, "are more than just reproductions of beautiful, aethereal paintings of worlds beyond. The present, the most accurate portrayal of those far-away heavenly bodies that modern science can offer."

For the incredibly low price of £12($16) you will receive 40 slides showing the golden age of Bonestell from the late 1940's to the 1960's, *plus a cassette tape* describing the pictures.

A selection of a dozen space photographs are available for only £1 ($2), post free.

Please note:

When ordering please specify colour, size, quantity, etc. as appropriate.

spaceflight

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01–735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

NOTICES OF MEETINGS

Full details on some of the meetings listed below are to be found inside the magazine.

Film Show

SPACE BENEFITS

The use of space technology has brought countless benefits to Mankind. A few examples will be examined in a two-part film programme.

Part 2, on **1 February 1984** 7.00–8.30 p.m. includes:

(a) Anatomy of Success
(b) Landsat: Satellite for All Seasons
(c) Hurricane Below
(d) David's World
(e) Space Navigation

Both parts will be screened in the Society's Conference Room, 27/29 South Lambeth Rd., London, SW8 1SZ. Members should apply in good time, enclosing a stamped addressed envelope.

Lecture
Title: **ARTIFICIAL INTELLIGENCE FOR INTER-PLANETARY MISSIONS**
by Tim Grant

The first of two lectures by a member of the Daedalus study team on artificial intelligence in space exploration. The second lecture (25 April) considers interstellar missions.

To be held in the Society's Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ on **28 March 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

Lecture
Theme: **EXPLODING STARS**
By A.T. Lawton
President of the Society

To be held in the Society's Conference Room, 27/29 South Lambeth Rd., London, SW8 1SZ on **4 April 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

One-day Symposium
Theme: **SPACE TRANSPORTATION SYSTEMS**

A one-day symposium on the above theme will be held in the Society's Conference Room on **11 April 1984**, 9.30-5.30p.m.

Offers of papers are invited. Potential authors are requested to contact the Executive Secretary at 27/29 South Lambeth Rd., London, SW8 1SZ.

Lecture
Title: **ARTIFICIAL INTELLIGENCE FOR INTER-STELLAR MISSIONS**
by Tim Grant

The second of two lectures by a member of the Daedalus study team on artifical intelligence in space exploration.

To be held in the Society s Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ on **25 April 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

History Meeting
Theme: **BRITISH ROCKETRY DURING THE SECOND WORLD WAR**

A number of contributions will be presented at a meeting on the above topic, which has been arranged by the Society's History Sub-committee. To be held in the Society's Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ on **2 May 1984**, 6.30-9.00 p.m.

Admission is by ticket only. A registration fee of £1.00 is payable, which will also cover the cost of coffee. Members should apply in good time enclosing a stamped addressed envelope.

Space '84
The Space '84 "weekend" will be held in Brighton on **16–18 November 1984**. See inside this issue for details.

LIBRARY

The Library will be open to members from 5.30–7.00 p.m. on the following dates:

1 Feb 1984
28 Mar 1984 4 Apr 1984
25 Apr 1984 16 May 1984

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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spaceflight

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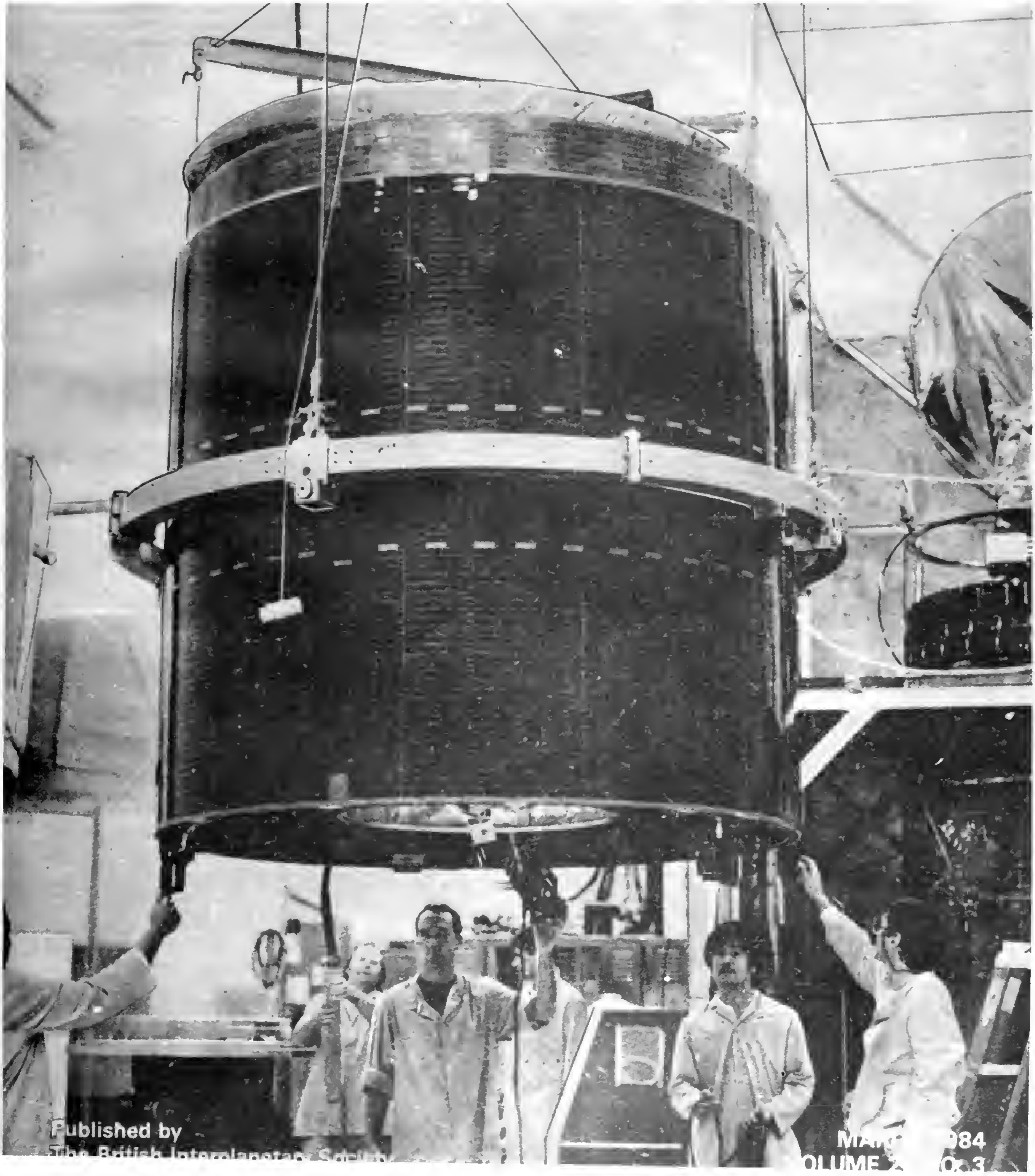
По подписке 1984 г.



BE A PART OF MAN'S JOURNEY INTO THE COSMOS

SPACE '84

16-18 November 1984

SPACE — THE FUTURE OF MANKIND

The success of Space '82 has encouraged us to organise Space '84 and provide another opportunity for our members and guests to become involved in space. Once more we will gather together a host of space experts, scientists and space popularisers to provide delegates with a unique view of what is going on in space today and how it will affect "The Future of Mankind." Space '82 saw astronaut Deke Slayton, former NASA Administrator Tom Paine, astronomer Patrick Moore and many others... Space '84 will be no less star-studded.

The theme will be "Space — The Future of Mankind," with individual sessions on:

- New Frontiers
- Discovering the Universe
- The Ways and Means
- Foothold in Space
- Advancing Frontiers
- The Future of Mankind
- Workshop (2 sessions)

Fuller details will be published in future issues of *Spaceflight* to keep all readers fully informed as our plans develop.

The Brighton Centre on the south coast will play host to the Society on **16-18 November 1984**, with its excellent facilities at our disposal.

To keep the friendly, intimate atmosphere of Space '82, the number of places available will be held down to 400. Experience shows that these will soon be snapped up, so early application is essential. Simply fill out the form below and send it to The Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

Yes, please send me a Registration Form and further details on Space '84.

Name: ....

Address: ....

....

....

SPACE '84

THE BRITISH INTERPLANETARY SOCIETY

spaceflight

A Publication of The British Interplanetary Society

Founded 1933 *Incorporated 1945*

VOL. 26 NO. 3 MARCH 1984 *Published 15 February 1984*

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CONTENTS

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THE WAY AHEAD

There is no doubt at all that a growth in membership will soon become one of our most pressing problems, for this is an integral part of our plans to extend the Society's influence, to enlarge its financial base and to make possible a new range of activities and publications.

The Society, being traditionally a Learned body, has not hitherto sought expertise in the marketing, promotional and advertising fields. This is a matter which should now be rectified, though with our long traditions of integrity, high standards and reliability all jealously safeguarded.

As a first venture the Society is adopting all the traditional methods of approach e.g. advertising in the technical and other press, the distribution of leaflets (so-called "mail shots") and, at the same time, seeking media publicity by other means, both directly and with help from individual members.

In no sense does the Council, or even our Society as a whole, possess a magic key to solve all these matters, hence the need to improve both our own organisation and activities and, at the same time, to seek additional help on as wide a basis as possible.

For some time the Council and Society's Administration have been preparing a developing programme for Society promotion designed to gather momentum as it moves along and yet be flexible enough to adopt any changes which experience dictates. Whatever we do from HQ, however, will always be only a part of this work. The Society's real strength lies "on the ground" and in the ranks of its loyal and dedicated members. These, if the task could be made more fully known to them would, the Council feel sure, be the ones able to contribute most effectively of all.

Our pages abound with ideas for help. Our accounts show our financial needs. Our Society News shows how we put our money to good use and our publications and meetings provide visible evidence of an ambitious and steadily improving programme. These are the reasons why we hope that more and more members will regard our major plans for development as something really worth doing. We want every member to feel intimately involved in all we do. Help us to keep up the good work.

COVER

Technicians at the Kennedy Space Center prepared the Palapa B-2 communications satellite for insertion into Shuttle Challenger for Mission 41B (formerly known as STS-11) in early February. The five man crew of Brand, Gibson, McCandless, Stewart and McNair were also scheduled to deploy the similar Westar 6 satellite and perform experiments with the German-built SPAS-01A, a modified version of the platform first flown on STS-7. The highlight of the eight day mission was to be a test of the Manned Maneuvering Unit backpack by Bruce McCandless in preparation for the satellite recsue planned for 41C (STS-13) in April.
NASA

CELEBRATING FIFTY YEARS OF THE BIS

The Society celebrated its 50th Anniversary with two Dinners last October. As it turned out, one was not a repeat of the other for each emerged as an independent function with a completely different character. Even the menus were different! The only factor common to both was the guiding hand of the Society's President, Tony Lawton, and the presence of both BIS and catering staff.

The Conference room was transformed for the occasion, with tables bedecked with flowers and candelabra and enlivened by the presence of an outsize birthday cake containing a beautiful dual motif to celebrate both the Society's 50th Anniversary and the 25th Anniversary of the National Aeronautics and Space Administration, both of which occurred in October.

Celebrations had originally been destined for one of the Inns of Court but these arrangements were discontinued when it became apparent that costs would be very high, so the decision was then made to attempt the formidable task of converting our Conference Room to a standard which would equate it with the facilities and the surroundings expected from a reputable hotel! It was a formidable operation but, as events subsequently showed, was undertaken with great success.

The opening Dinner, on 21 October, brought forth a galaxy of Guests of Honour attending to wish the Society well. Foremost among these was Phil Cleator, the founder of our Society and as amazingly virile as ever; Dr. David Hughes, of Halley's comet fame; Allen Jefferis, Chief Executive, Satellite Systems, British Telecom International, and Reg Turnill, the well-known writer and broadcaster who moved the Toast "To the Society — Its continuing success for the *next* 50 years."

Other distinguished figures included Roy Gibson, formerly Director-General of the European Space Agency and Charles Tharratt, previously Chief Engineer of the Black Arrow project at Saunders-Roe (now the British Hovercraft Corporation) who was visiting the UK to join, with others, in celebrating the 25th Anniversary of the Black Arrow programme as well. For good measure, Charles brought greetings from those attending the Black Arrow celebrations, particularly appropriate to us for our Society strongly advocated this all-British space activity and was greatly concerned when it was cancelled. Representing the Council were Les Shepherd, Rex Turner, Gordon Thompson and Gerry Webb, together with many representatives of Society committees.

Presentations made at the Dinner included a Message from the Board of Directors of the American Institute of Aeronautics and Astronautics (AIAA), signed by them in the form of a Scroll which was framed and displayed, together with the Message from the NASA Administrator James M. Beggs, which had marked the Opening of our 50th Anniversary year on the occasion of Space '82 and which included flags and a crew patch from the third Space Shuttle flight.

Among the messages which arrived was one from Arthur C. Clarke which read:

> "Congratulations on your 50th Birthday. Please don't change to "Interstellar" until your 100th..."

Other gifts included four excellent satellite models from Reg Turnill, which immediately found places of honour on the top table, and no less than 150 wine glasses from

Tony Lawton, the Society's President, moves in for the kill on the Anniversary cake, which not only marked 50 years of the BIS but also 25 years of NASA.

Western Glass International, donated in good time *via* the good offices of Wally Horwood, to enable them to be pressed into use immediately!

Also from afar was a message from the New Zealand Spaceflight Association which read:

> "Congratulations on the British Interplanetary Society's 50th Anniversary; from small beginnings to a Society of prestige, which is world known. Giving an insight of past, present and future, in all of its particular fields. May your staff, and members throughout the world have the enjoyment of having to look forward to another fifty years of your achievements, which could be the most exciting to date."

October 22nd saw a new galaxy of Guests of Honour, including Professor John Houghton, until recently Director of Rutherford Appleton Laboratories and now rejoicing in his new appointment as Director-General of the Meteorological Office, Fred Durant who was, until recently, Asst. Director and Head, Astronautics Dept., of the National Air & Space Museum in Washington D.C. and Fred Ordway, Technical Advisor to the film "2001." Also present was Peter L. Hickman, Managing Director of the Space and Communication Division of British Aerospace at Stevenage, now responsible for some 1600 people and an order book valued at about £300 million. Others present included Martin Fry, Chairman of the Programme Committee, Alan Lewis, Chirman of the Society's Facilities Committee and Tim Grant, representing the Council. Many members came from afar.

MILESTONES

December 1983

1 NASA Administrator James Beggs briefs Pres. Reagan and the cabinet on plans for a space station. The President is expected to include provisions for a station in the budget he sends to Congress in January. It is reported that the administration is also inclining towards a prestige project such as a manned lunar base.

2 A 111 sec firing of an Inertial Upper Stage 2nd stage is performed to test the nozzle system. Two further firings are planned. The nozzle steering failed in the IUS staged used in the STS-6 mission in April 1983.

8 Shuttle *Columbia* lands at Edwards Air Force Base on runway 17 at 23.47 GMT to end the 10 d Spacelab 1/STS-9 mission; the original landing time of 16:00 GMT was missed because of computer problems aboard the craft. Landing weight was 99,966 kg — the heaviest so far. The four non-pilots immediately began medical tests. *Columbia* due to be shipped back to Florida on 12th. It was discovered after landing that a small fire had broken out in a rear compartment housing the Auxiliary Power Units.

20 NASA confirms that the Landsat 5 Earth resources satellite will be launched by a Delta 3920 rocket from California on 1 March 1984 to replace the failing Landsat 4. The launch will also allow the University of Surrey's second UOSAT satellite to go into orbit — designed and built in under 5 months. UOSAT will carry further educational experiments.

20 The Cosmos 1514 satellite, launched on the 14th, returns its live passengers to Earth. Two monkeys, Abrek and Bion, were in this international mission to investigate adaption to weightlessness.

20 At a Kennedy Space Center press conference, the launch date of Shuttle 41B (formerly STS-11) is 1 February. NASA still has to complete a detailed analysis of the fire aboard *Columbia* at the end of STS-9. McCandless and Stewart will perform EVAs without tethers and a 2 m balloon will be used for rendezvous tests.

22 The US ISEE 3 satellite makes its third pass by the Moon (the first two were on 21 Sep and 21 Oct) to move into an orbit to take it towards Comet Giacobini-Zinner in September 1985.

28 NASA are studying the possibility of diverting the Galileo Jupiter probe to fly past an asteroid on its way through the Asteroid Belt between Mars and Jupiter. However, the craft needs to conserve propellant for manoeuvres at Jupiter and it may be that asteroids are surrounded by clouds of debris.

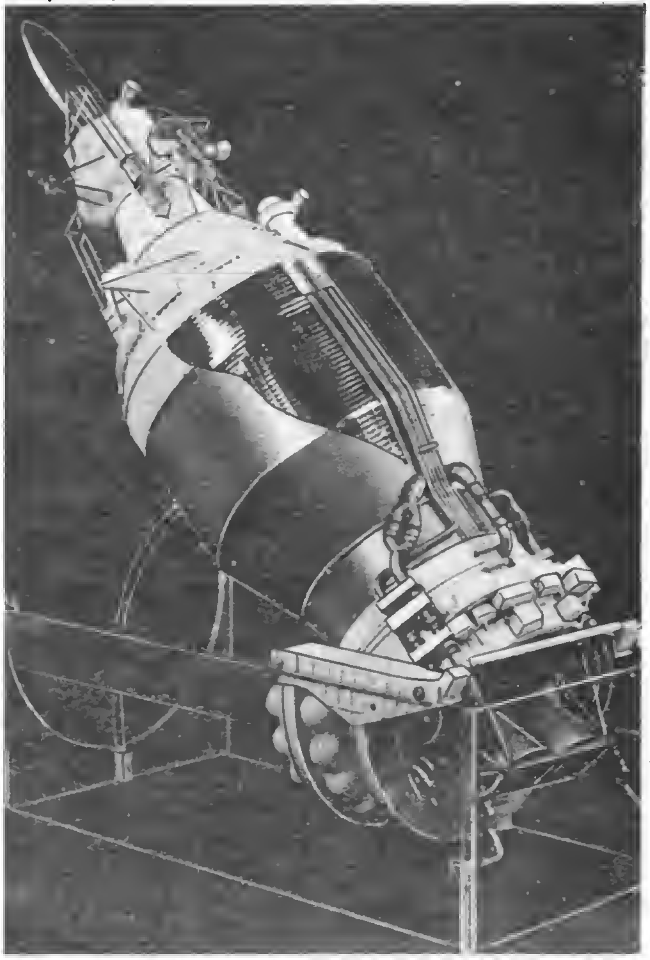
January 1984

2 It is reported that the Soviets tested another subscale shuttle orbiter last week (previous orbital and reentry tests were in June 1982 and March 1983). The reentry craft of Cosmos 1517 splashed down in the Black Sea.

2 The Ariane L8 launch with the Intelsat F8 communications satellite is delayed until 8 Feb: because the F7 satellite, in orbit, is revealing noise problems in its transmissions.

DO YOU KNOW?

A mass of tankage and plumbing with a delicate spacecraft perched on top. But what is it? Answer below the picture.



Answer: it is a model of the Galileo Jupiter craft on a Centaur upper stage ready for launch from the Shuttle cargo bay. The Centaur liquid oxygen/hydrogen stage has already seen extensive service aboard Titan and Atlas launches.

DO YOU REMEMBER?

25 Years Ago...
28 February 1959. Discoverer 1 is launched from California to become the first polar-orbiting spacecraft.

20 Years Ago...
3 March 1964. Gemini 1 arrives at Launch Complex 19 at the Cape for installation on top of its launcher.

15 Years Ago...
3 March 1969. Apollo 9 is launched on a 151-Earth orbit mission to rehearses rendezvous and docking manoeuvres with a lunar module.

10 Years Ago...
9 March 1974. A Scout launcher places the British X-4 Miranda technology satellite in orbit from California.

5 Years Ago...
7 March 1979. NASA/JPL announce that Voyager 1 has discovered a thin ring surrounding the planet Jupiter.

K.T. WILSON

CORRESPONDENCE

Age-old Rockets
Sir, When making the opening speech at Space '82 I mentioned that the poet George Gordon (Lord Byron) made a remarkable prophecy on astronautics and space travel in 1823, some 166 years before Man set foot on the Moon. In one of his poems he concluded the verse with the line "And full soon, steam engines will conduct him to the Moon."

The Saturn 5 rockets that sent the Apollo Lunar Modules to the Moon *were* driven by steam — using liquid hydrogen and liquid oxygen these stages *are* literally "steam engines."

Many friends have asked for details of Byron's poem and I quote the appropriate verse below. It is a section of "Don Juan — Canto the Tenth" Verse 2:

Man fell with Apples and with Apples rose
If this be true; for we must deem the mode
In which Sir Isaac Newton could disclose
Through the then unpaved stars the turnpike road
A thing to counterbalance human woes
For, ever since, immortal man hath glow'd
with all kinds of mechanics, and full soon
Steam engines will conduct him to the Moon.

This was one of his last poems, for Byron died on 19 April 1824. The Age of Steam was about to begin for the world's first public railway (the Stockton and Darlington) was opened in 1825 and the widely famed "Rocket" steam locomotive was built in 1829.

A.T. LAWTON
President, BIS

Changes to Spaceflight
Sir, I would like to say how much I feel that *Spaceflight* has improved over the last twelve months. Not being particularly technically minded, I at first found many of the articles written too far above me for my enjoyment. During the last 12 months I have found the balance of the magazine much improved and it seems to be that either my technical knowledge is improving (I like to think so) or that the articles are aimed at a wider audience.

I congratulate you and your staff on an excellent magazine which has become very professionally-produced.

F.W. SCOWEN
Notts

Cost in Orbit
Sir, The letter by R.C. Parkinson, on p.294 of your July/August 1983 issue, made a very important point. The cost per unit weight into orbit is the key to a breakthrough in space exploration/utilization. Development of the Shuttle was based on a budget compromise; in order to prove the vehicle's feasibility with severely reduced funds, NASA had to sacrifice full reusability. The result: high operating costs.

Now that that breakthrough is achieved, and the Shuttle is proven to be feasible, we ought to aply all the lessons learned, and all the advances made in the meantime in materials technology and all other fields to build a fully reusable shuttle system with transport costs at about $200/kg. Even at that level, there would be thousands who would want to make a trip into orbit; more importantly, the economics of expanding space operations would change radically. The *Aviation Week* of November 1983 (p.44) reported on studies in this regard by NASA (and the USAF), with hints, again, of a cost reduction by an order of magnitude in sight.

LASZLO TETMAJER
Montana, USA

A relevant paper by Dr. R.C. Parkinson was included in the February 1984 JBIS. *We include an article by David Ashford on "Space Tourism" in this issue. Both papers dwell on the importance of low cost-to-orbit systems.*

Speaking on a Platform
Sir, The highly informative "Satellite Digest" series unfortunately perpetuates a small but significant error. The description of the SPAS-01 flight (see *Spaceflight*, December 1983, p.465) describes the unit as 'based on Spacelab pallet.'

Although both structures are pallets in the general sense, the resemblance ends there. The Spacelab Pallet is a semi-monocoque, open U-shaped structure, 3 m long. SPAS uses a modular bridge-type structure based on cube-cells with a side of length 0.7 m. When equipped with experiments, it occupies 1.5 m of the payload bay. It was conceived and developed by the space division of MBB as a commercial venture, with support from the German Ministry for Research and Technology (BMFT).

SPAS will be flying again in the near future, aboard STS-11. It will then be designated SPAS-01A, to denote a reflight of SPAS-01 with a slight change of payload.

C.R. GILBERT
Marketing Dept.,
MBB/ERNO Bremen

End of Apollo
Sir, What happened to the experiment packages left on the Moon by the Apollo astronauts? We never seem to hear of them these days.

D.E. WATSON
Bristol

The ALSEP (Apollo Lunar Surface Experiments Package) units left by Apollo 12, 14, 15, 16 and 17 crews between November 1969 and December 1972 were switched off at the end of September 1977. By that time, the seismic sections had detected some 12,000 Moonquakes. The cost of continuing to receive the data was not considered to be worthwhile.

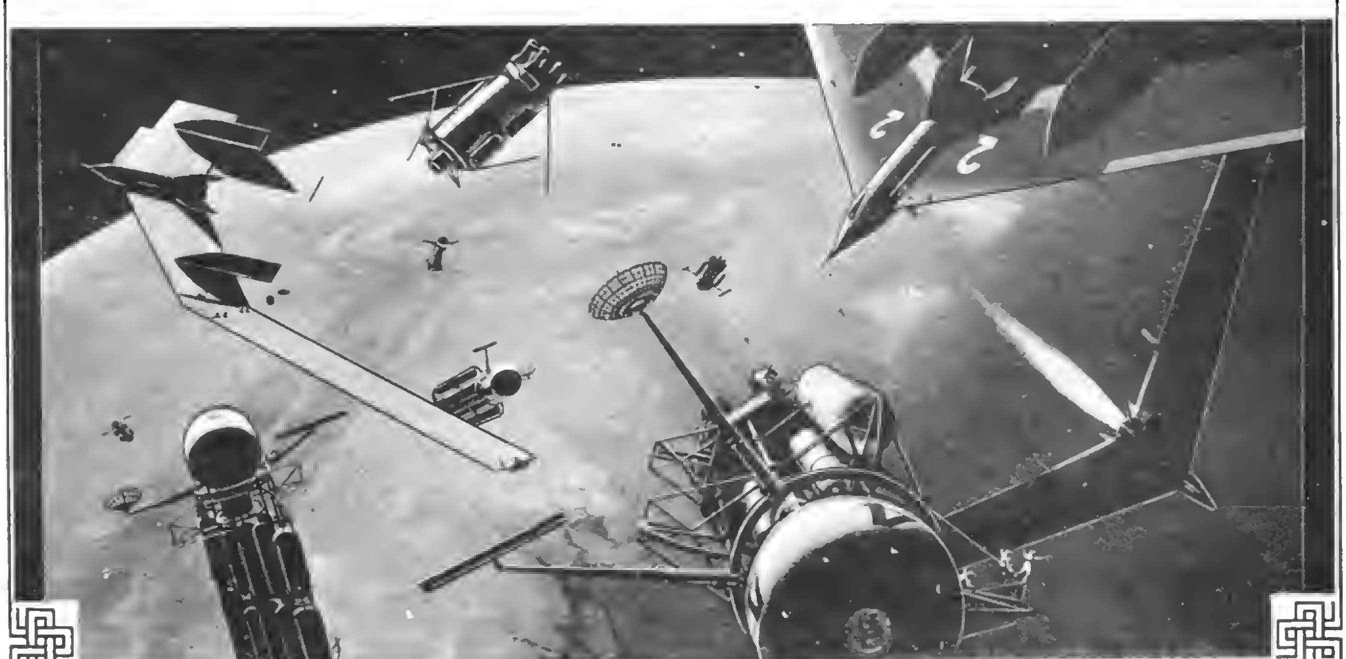
SNIPPET

Mind the Step
Sir, How nice the new tiles on the steps on the HQ look (*Spaceflight* December 1983). But on closer inspection I notice a bucket left there. Is one to assume that on leaving the building visitors are being encouraged to clean up their footmarks behind them!

YVONNE COOPER
Surrey

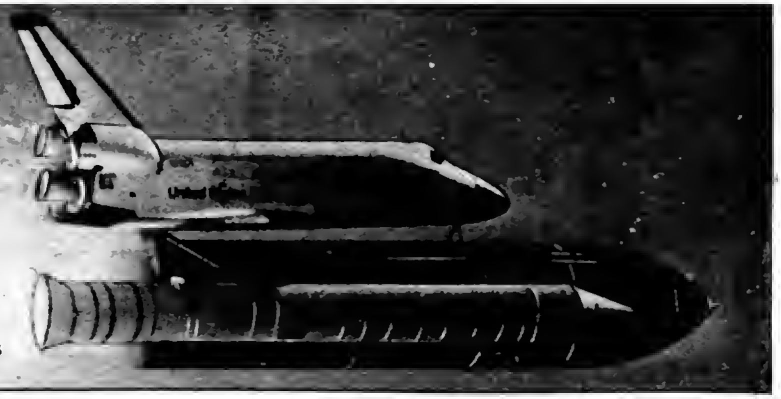
The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

VISION OF SPACE



SPACE REPORT

A monthly review of space news and events



SPACELAB 3 HARDWARE

Two Spacelab 3 flight racks, housing two materials processing experiments, were shipped to the Kennedy Space Center in November for integration into Spacelab 3, due for a 7 day mission in November.

The Fluid Experiment System (FES) and the Vapour Crystal Growth System (VCGS) experiments have already undergone final development testing and integration into the flight racks following delivery to the Marshall Space Flight Center from the TRW Corporation in October 1982. The FES and VCGS are two of 13 experiment systems that make up the Spacelab 3 mission.

The availability of the experiment systems at Marshall provided an opportunity for Spacelab 3 payload specialists to train on the hardware. Marshall scientist-engineer Dr. Mary Helen Johnston and Dr. Lodewijk van den Berg of EG&G are the two materials sciences payload specialists named for the mission.

"As often as feasible the payload specialists were able to work on the equipment," said John Price, Marshall FES-VCGS project manager. "This is the first time they have been able to do that in preparation for this mission."

The FES is designed to grow crystals of triglycine sulphate as part of a study to develop a growth technique for such crystals in low-gravity. These crystals are used in infrared detectors.

The VCGS is designed to grow a crystal of mercuric iodide of better quality than those grown under terrestrial conditions. Similar crystals grown on Earth are used in radiation detectors.

Once at the Kennedy Center, post-shipment tests to check on the health of the experiments took about six weeks. The racks were scheduled to begin the integration process with Spacelab 3 in late December.

(The Spacelab 3 mission will take place before *that of Spacelab 2 — Ed.)*

WEATHER SATELLITES

The US Air Force has ordered four Block 5D-2 DMSP (Defense Meteorological Satellite Program) weather satellites from RCA Astro-Electronics in a contract worth $171 million.

Twenty two DMSP satellites have been orbited since the first Block IV satellite in 1966, and the spacecraft have gone through a steady evolution in size, weight and capability. The current models are known as "smart" satellites. They perform their work autonomously, using a reprogrammable computer to handle diverse tasks and solve unforeseen problems.

The Block 5D-2 satellites have a larger number of sensors than their predecessors, and are designed to operate for three years — twice the design lifetime of earlier DMSP satellites.

These satellites provide "live" weather information, with a resolution of up to 500 m and cover every part of the Earth at least twice daily from the vantage of their polar orbits.

VENUS PROBE CONTRACTS

The two major contracts for NASA's Venus Radar Mapper mission, due to be launched by Shuttle in 1988, have been awarded. Martin Marietta will build the orbiter bus for $120M, while Hughes will produce the radar system for $49M.

Meanwhile, the Soviet Venera 15 and 16 probes continue to return radar pictures of the Venusian surface with a resolution of 2 km.

SHUTTLE CREW CHANGES

As noted on p.19 of the January issue, extensive changes in the crews selected for Shuttle missions have taken place. NASA also now no longer announces the missions according to STS number — the old STS-16, for example, is now 41F. The '4' indicates a 1984 launch (the NASA year running from October 1983), the '1' a Canaveral origin ('2' = Vandenberg in California), 'F' the sixth flight originally planned for that year.

The STS-13 crew of Crippen, Scobee, Nelson, Hart and Van Hoften stays the same for the mission that will repair the SMM solar observatory satellite in April. STS-12 no longer exists because of the Inertial Upper Stage problems, but Hartfield, Coats, Resnik, Hawley, Mullane and Walker have been moved *en bloc* to 41D (STS-14) to handle the Telesat and Syncom 4-1 satellites in June. The original STS-14 crew of Bobko, Williams, Seddon, Hoffman and Griggs are moved to 41F (the old STS-16) for the Telstar 3C, SBS-D and Syncom 4-2 communications satellites. It appears that the old STS-15 reserve slot will not be filled.

Mission 41G (the old STS-17) will be flown by Crippen, McBride, Sullivan, Ride and Leestma on 30 August. Kathryn Sullivan will become the first women to make a spacewalk, with David Leestma, when she takes part in a demonstration of refuelling in space. Note that this will also be the first flight with two women; Sally Ride will be making her second trip into space.

Mission 41H (the original STS-18) will orbit either the second TDRS communications satellite or a military payload on 29 September. If the former, then Hauck, Walker, Allen, Gardner and Anna Fisher (all originally

assigned to STS-16) will fly. If the latter, then the military team of Bobko, Grabe, Mullane, Stewart and Hilmers could take over.

Brandenstein, Creighton, Shannon Lucid, Fabian and Nagel will fly 51A (the old STS-19) on 24 October with Telesat-H and a materials science laboratory. Mission 51C on 20 December will see Joe Engle command his first crew, of Covey, Buchli, Lounge and Fisher. They will carry either the second or third TDRS satellite.

Spacelab 2 on 29 March 1985 will be flown by Fullerton, Griggs, Musgrave, England and Henize.

EARTH-SUN STUDIES

The US, Europe and Japan moved a significant step closer to an international solar-terrestrial space research programme last October when delegates discussed plans at a meeting of solar and space physics scientists held in Washington, D.C. Participants represented the three space research organisations: the European Space Agency (ESA), the Institute of Space and Astronautical Science (ISAS) of Japan and the US NASA. For several months they have been formulating plans for a coordinated solar-terrestrial space programme which would result in a combined international effort.

The purpose of this trilateral meeting was to develop a research programme to recommend to ESA, ISAS and NASA for further consideration. The committee reviewed the existing programmes and project plans of the three space agencies and identified ways of combining related elements into a cost-effective and scientifically coherent strategy.

Two projects currently in the planning stage at ESA are potential elements of this international effort: a versatile solar observatory and a cluster of four Earth orbiting spacecraft to study basic plasma physics processes.

ISAS of Japan would also have major involvement by providing one of the primary spacecraft for the coordinated effort. ISAS would develop and operate one of the spacecraft, which would be launched by NASA with the Shuttle. The US science delegation is recommending major satellite and payload contributions by NASA. Recommendations are for a 1986 start for this major study of the Sun-Earth relationships.

SATELLITE RESCUE CENTRE

Argentina has become the first country to have a Rescue Co-ordination Centre (RCC) equipped for maritime satellite communications. With its newly-commissioned ship Earth station, the RCC is able to contact vessels similarly equipped in seconds in the event of a distress or emergency at sea. The RCC, located at Puerto Belgrano, now has direct access to the satellite system operated by Inmarsat, of which Argentina is a member. Forty countries in all are members of the London-based organisation.

Inmarsat provides the satellite capacity for telephone, telex, facsimile and data communications to the worldwide shipping and offshore industries. It also gives priority to distress alerts, so that a ship equipped with a ship

The crew of STS-13 (now termed Mission 41C) take a break during their emergency escape training at the Kennedy Space Center. From left: James van Hoften (Mission Specialist), George Nelson (MS), Bob Crippen (Cdr), Terry Hart (MS) and Dick Scobee (Plt). Note that a '1' has been added to the armoured carrier's '3' to make it more appropriate for the mission. Bob Crippen will be making his third flight; he flew with John Young on STS-1 in April 1981 and commanded STS-7 in June 1983. He will also command STS-17 next August. The other crewmen are all making their first trips into space. The mission will deploy the large Long Duration Exposure Facility (LDEF — see p.14 of January's issue for a picture) from the cargo bay. Its self-contained experiments will run until retrieval by the Shuttle next February. *Challenger* will also rendezvous with the malfunctioning SMM solar astronomy satellite and George Nelson will use a manoeuvring backpack to approach the rotating observatory and dock with it. Nelson having stabilised the target, *Challenger* will move in to use its robot arm to grapple with a docking point built into SMM and berth it in the cargo bay. Nelson and Hart will replace the faulty 230 kg attitude control unit and SMM will be sent on its way to continue its solar work. *NASA*

Earth station can be connected in seconds with rescue authorities on shore.

Most maritime countries have rescue co-ordination centres, which are expected to be equipped with ship Earth stations over the next few years. Inmarsat Director General Olof Lundberg said, "The main inpetus for this move towards satellite communications will come with the Future Global Maritime Distress and Safety System (FGMDSS), which is being developed by the International Maritime Organization (IMO) and in which Inmarsat will play a major role."

The FGMDSS is targetted for introduction in 1990. The system is aimed at increasing safety of life and property at sea through improved communications and improved search and rescue arrangements. Once a distress alert is received by the rescue co-ordination centre *via* either satellite or conventional communications, the RCC would alert the coast guard and other ships in the area of the stricken vessel and co-ordinate the rescue efforts.

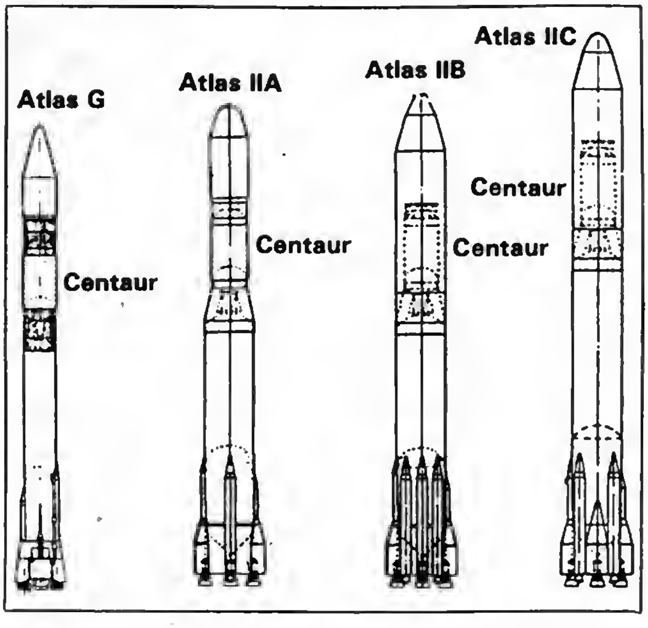
Under the FGMDSS, Morse radio-telegraphy is expected to be replaced by more avanced communications techniques using terrestrial or satellite communications. Distress alerting will primarily be by means of satellite radio beacons, which can be carried on ships and lifeboats and which would float free from a sinking ship. The objectives of the FGMDSS are to ensure that any properly equipped ship can be located with minimum delay, to provide a worldwide search and rescue network and procedures, and to enable the dissmenination of relevant navigational and weather information to ships.

NEW ATLAS IN USE

The launch of the Intelsat 5 communications satellite early this year introduced the use of a new type of Atlas Centaur launch vehicle. The Atlas G booster is 208 cm longer than the older D version. Combined with the Centaur upper stage it can take 2360 kg into a geostationary transfer orbit, compared to the 2000 kg of its predecessor.

General Dynamic Convair are studying the possibility of introducing yet more powerful versions on a commercial basis. They estimate that one third of the 200 communications satellites expected over the next decade will require a launcher of their size.

The Atlas IIA Centaur, with two strap-on solid boosters and an Atlas diameter of 4.3 m, could handle 4080 kg into geostationary transfer orbit and be available in 1987. The IIB version would carry six boosters to handle 5080 kg, while the IIC would carry four strap-ons, have a longer first stage *and* use two more main engines.



The Centaur upper stage itself is also being considerably modified. The G version is being produced for the Dept of Defense to handle 4800 kg into geostationary orbit while the G-prime is for NASA missions (such as the Galileo Jupiter orbiter) to handle 6350 kg into the same orbit. A Centaur J version is being studied for use with commercial communications satellites.

The last launch of the old Atlas D Centaur on 19 May 1983 with an Intelsat 5 satellite marked the 42nd consecutive of the Centaur out of a total of 68 flights.

(The above information was drawn from "The Commercial Centaur Family" by W.F. Rector and D.E. Charhut, presented at the 1983 IAF Congress in Budapest).

SHUTTLE TRANSPORTER

NASA has awarded a $1.3 million contract to the Italian Cometto company to build a transporter for the US Space Shuttle. The contract calls for the company to design, develop and manufacture a giant transporter which will be used in Shuttle operations at Vandenberg Air Force Base, California. The transporter will carry the Shuttle Orbiter, with payloads installed, on the 27 km trip from the North Vandenberg Maintenance and Checkout Facility to the launch pad located on South Vandenberg.

The transporter will be the first of its kind ever developed. Because it must be built to travel across the hilly California terrain and a portion of road it must cross on its journey to the launch pad, it will be different from the crawler/transporters used in Shuttle operations at Cape Canaveral.

The carrier will be built so that the Orbiter can be mounted to the bed of the transporter in a horizontal position. The bed will have the capability of being lowered or raised so that the Orbiter will remain level at all times to protect the payloads which are being transported to the pad

SHUTTLE *ENTERPRISE*

Shuttle Orbiter *Enterprise*, used for a series of drop-tests in 1977/78 but destined never to fly in space, will be a star exhibit at the World Exposition in New Orleans from 12 May to 11 November. The Orbiter will be transfered from Edwards Air Force Base in California on the back of NASA's 747 transport aircraft to a waterway linking to the exposition site on the banks of the Mississippi. The final stage of the journey will be made by barge.

SHUTTLE ABORT LANDING SITE

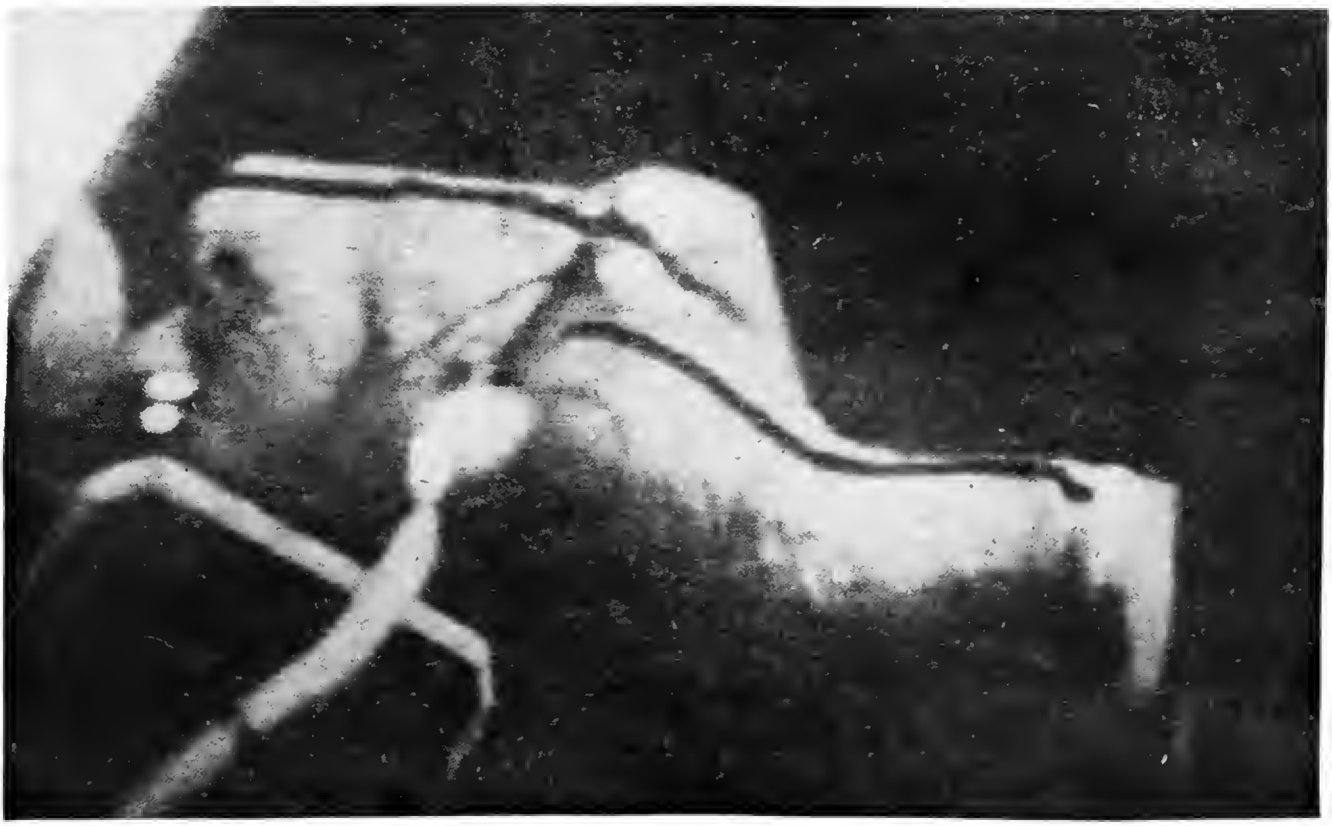
In the STS-8 mission last September, *Challenger*'s crew photographed remote Henderson Island in the south Pacific Ocean to survey it as a possible Shuttle abort landing site for polar orbit launches from Vandenberg Air Force Base in California. The concern may have been prompted in part by the 1981 novel *Shuttle Down* by Lee Correy in which a Shuttle out of Vandenberg has to make an emergency landing on Easter Island in the Pacific due to lack of a suitable contingency site, writes Joel Powell. Henderson Island is a British territorial possession (location 23°S, 128°W).

US COMET PROBE

As mentioned previously by Dr. Bill McLaughlin in our regular "Space at JPL" feature, the possibility of flying a US comet rendezvous mission is being investigated. There is no American probe to investigate Halley's comet in 1986 but the ISEE 3 satellite has been diverted to approach Comet Giacobini-Zinner next year.

This picture is an artist's concept of a Mariner Mark II craft rendezvousing with Comet Honda-Mrkos-Pajdusakova in 1995. Another, slightly different, design is being considered for the alternative target of Comet Kopff — the choice of comet to aim for will be made on 1 February.

Our thanks go to [illegible] of the Jet Propulsion Laboratory in California for the picture and information.



Above: Soviet cosmonaut Alexander Alexandrov working outside the Salyut space station last November to install extra solar power panels. It now appears that power problems forced Alexandrov and Lykhov to live in cool (18°C) and damp conditions for the last part of the mission. The intended Soyuz T-10 launch with Titov and Strekalov on 28 September was apparently to add new panels after special training for the new crew. Unfortunately the Soyuz booster caught fire on the pad after a propellant valve failed to close and the crew and their craft had to be pulled away by escape rockets. The new panels were eventually sent up in the unmanned Progress 18 ferry and the Salyut occupants had to do the job themselves. Without the additions, further missions might have been impossible. The two cosmonauts returned to Earth on 23 November as planned. *Below:* Lyakhov (right) and Alexandrov aboard Salyut 7. *NOVOSTI*

CENTAUR UMBILICAL

A new umbilical line to service the Centaur upper stage inside the Space Shuttle is now being tested at the Kennedy Space Center, writes Joel Powell. To be installed on the Fixed Service Structures at both Shuttle launch pads, the 10 m telescoping umbilicals will deliver liquid hydrogen and oxygen to an access port just forward of the left Orbiter OMS pod. Expected to cost $100 million, the new installations are scheduled to be ready for the Galileo and International Solar Polar Mission launches in May 1986 from Pads 39A and B.

ASTEROID DISCOVERY

Another Earth-approaching asteroid has been discovered under the World Space Foundation's, Asteroid Project. Dr. Scott Dunbar made the discovery with the 1.2m Schmidt telescope at Mt. Palomar while working on the Planet-Crossing Asteroid Survey team with project Principal Investigator Eleanor Helin.

The asteroid is of the Amor class, meaning that its orbit brings it near the Earth's orbit from time to time. Apollo asteroids, by comparison, periodically cross the Earth's orbit. While not a particularly good candidate for a rendezvous mission, it is a remarkable object because of its brightness. Preliminary measurements suggest that it is two or three times brighter than other objects of the same size, and that it is about 640 m in diameter.

Other significant discoveries by Asteroid Project-supported researchers in 1983 include:

1983 LB — Amor class, discovered by Steve Swanson, June 12/13
1983 LC — Apollo class, discovered by E.F. Helin, June 12/13
1983 LD — Hungaria class, discovered by E.F. Helin, June 12/13
1983 PA - Phacaea class, discovered by E.F. Helin, August 7/8

1983 PA is of special interest for several reasons. It is a very deep Mars-crosser with a high inclination, and it is very bright.

ARIANE LAUNCH SCHEDULE

The launch list for Europe's Ariane satellite carrier over the next two years shows that the vast majority of payloads are communications satellites. The only other satellites in the list here — correct as of November 1983 — are Giotto (Halley's comet probe), SPOT (French remote sensing) and Viking (Swedish, magnetospheric experiments).

The updated Ariane 3 version will be introduced in the L10 launch — note the double payload — while the Giotto probe will use the old Ariane 1 left over after the Exosat astronomical satellite was transferred to a US Delta.

The Ariane 4 model is due to be introduced in February 1986 with L22.

1984		
Mar	L 9	Intelsat 5 F9
May	L10	Spacenet 1 + ECS 2 or Telecom 1A
Jul	L11	Gstar 1A + Telecom 1A or ECS 2
Sep	L12	Spacenet 2 + Marecs B2 or Arabsat
Nov	L13	Gstar 1B or Telecom 1B + Arabsat or Marecs B2
1985		
Jan	L14	Telecom 1B or Gstar 1B + opportunity
Feb	L15	SBTS 1 + Spacenet 3
Apr	L16	SPOT 1 + Viking
Jly	L17	Giotto
Aug	L18	SBTS 2 + ECS 3
Sep	L19	TV Sat
Nov	L20	TDF 1

BLACK HOLE POWER HOUSE

After studying ultraviolet light from a nearby galaxy, by means of the International Ultraviolet Explorer satellite, research has reached the conclusion that the quasar-like heart of the NGC 4151 galaxy is powered by a black hole some 100 million times heavier than our Sun.

Although UK and US astronomers working at the Kitt Peak National Observatory in Arizona proposed the existence of a massive black hole in another galaxy (M87) a few years ago, this is the first time that astronomers have actually 'weighed' the centre of a quasar, and the discovery strengthens the theory that the immense and concentrated power of a quasar is due to gas swirling around a very massive black hole in the centre of a galaxy.

To weigh the centre of NGC 4151, gas clouds very close to the core were observed. It was found that the clouds are moving at speeds up to 14,000 km/s.

It has been calculated that the slower-moving gas clouds lie farther from the core — just as the slowest planets in the Solar System are those that are farthest from the Sun. This means that there is some very massive object at the centre. The speeds and distances of the clouds show that this object is 100 million times heavier than the Sun — and the only kind of object which can be so massive, yet sufficiently small, is a black hole.

In 1969 Professor Donald Lynden-Bell proposed that quasars are caused by black holes at the centres of galaxies. Gas from the galaxy spirals inwards, under the influence of the black hole's gravity, and in the process becomes hot and emits radiation. The most powerful quasars would have a black hole 500 million times heavier than the Sun. Such quasars are rare, however, and lie far away from us, towards the edge of the known Universe. Many more galaxies should have smaller central black holes, around 50 to 100 million Suns in mass. Such a black hole could cause a "mini-quasar" at the centre of an otherwise normal galaxy.

NGC 4151 fits this description exactly. It is a spiral galaxy, similar to our Milky Way, lying some 50 million light years away in the direction of the constellations Canes Venatici. But, unlike the Milky Way, NGC 4151, has a central "mini-quasar" core: a very small, very bright region where gas clouds move at high speed. Astronomers call such galaxies Seyfert galaxies — and NGC 4151 is the nearest bright example.

SHUTTLE WORK AT VANDENBERG

By Curtis Peebles

Within sight of cows grazing on wild flower-covered hills, construction work is nearing completion on the US west coast Shuttle facility at Vandenberg Air Force Base. From this pad, Shuttles will go into polar orbit carrying various payloads, including weather, Earth resources and military satellites. The author brings us up to date with how the work is progressing.

Slick-6

The history of the Shuttle pad at Vandenberg goes back to the mid-1960's. Space Launch Complex-6 (SLC-6), better known as Slick-6, was originally built for the Air Force Manned Orbiting Laboratory project. When that was cancelled in June 1969, the Pad and Mobile Service Tower were mothballed. SLC-6 would remain in that condition for ten years. Then, in 1979, work began on modifying it for use by the Space Shuttle. SLC-6 had to be modified heavily for its new role. Only one flame duct, blockhouse and the basic structure of the Mobile Service Tower were useful. Nevertheless, this still saved $100 to 200 million.

Some 20 to 30 m were cut off the Mobile Service Tower, new work platforms were added and a 200 tonne capacity bridge crane was installed to handle the Shuttle elements.

The facility had to be designed almost from scratch. The design that finally emerged is the reverse of that found at the Cape. There the Shuttle is assembled in a building, then rolled out to the pad. At Vandenberg, the Shuttle is assembled on the pad and the buildings are moved back on rails.

The Solid Rocket Boosters are stacked on the pad by the Mobile Service Tower crane. The External Tank and then the Orbiter are lifted and rotated from the horizontal into the vertical by the Mobile Service Tower and Shuttle Assembly Building. During this process, the pad area is enclosed by the two buildings. The huge Shuttle Assembly Building, a box-like structure, is meant to protect the Shuttle from weather during assembly. A major problem at Vandenberg is winds that can reach 55 km/hr, making the delicate assembly job impossible. The Shuttle Assembly Building is a comparatively late addition, emerging in late 1981/early 1982.

The Payload Changeout Room is used to load the Shuttle's cargo. This is its only job although it was originally planned that it would help with the assembly of the Shuttle. The cargo (up to three at any one time) are readied in the Payload Preparation Room (actually a large building). When the cargo is ready, the Payload Changeout Room is brought up and the cargo lifted in by an elevator. The Changeout Room rolls out to the pad, through the Shuttle Assembly Building, and the cargo is placed in the Shuttle. When the process is completed, the elements move away from the pad to their respective parking areas. They are uncomfortably close to the violence of the Shuttle's launch. The Mobile Service Tower is 80 m away, the Shuttle Assembly Building even closer at 60 m; the Changeout Room is parked at the Payload Preparation Room, 230 m away. Launch is controlled from a blockhouse (i.e. a blast-protected building), also

The Slick-6 pad area in the early days of construction. Central foreground shows the flame pit; at right is the Access Tower.
United States Air Force

left over from the MOL programme. This is another difference from the Cape; there, the launch is controlled from a conventional building. The entire Slick-6 complex is contained within a limited area compared to the Cape which sprawls across literally miles of the flat Florida landscape.

Construction Status

At the end of August 1983, Slick-6 was nearing completion. The Shuttle runway was finished and the Orbiter Maintenance and Checkout Facility nearly so. The Launch Pad, Access Tower, Payload Preparation Room, the Cyrogenic Tanks and Flame Ducts were all 98% completed. The Payload Changeout Room and Gas Storage Area were scheduled for completion by the end of September. The Assembly Building is the only part not in such an advanced state; work on it was only 20% completed.

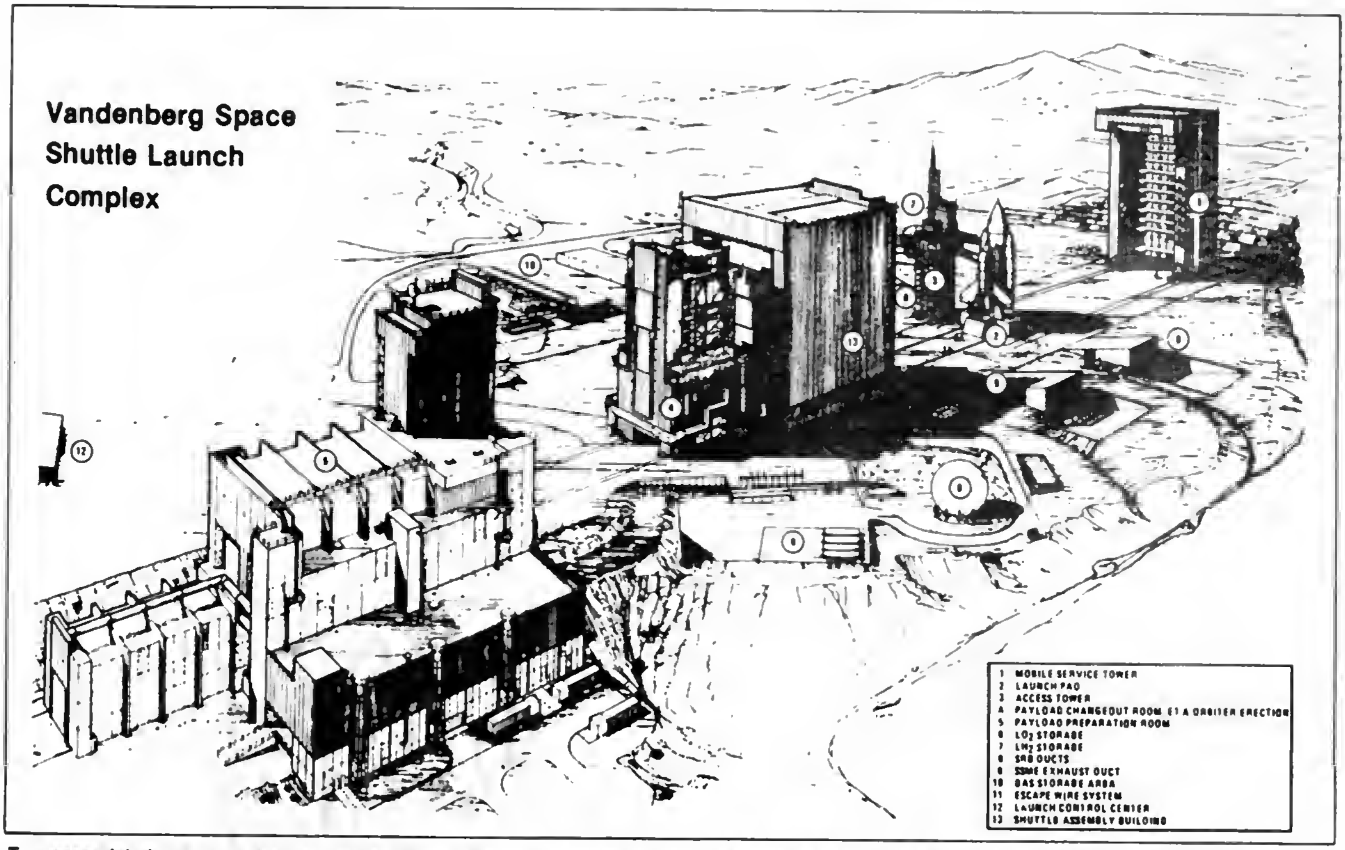
Over 600 contractor personnel are working on SLC-6. The effort has involved 8,000 m^3 of concrete and 24,000 tonnes of re-enforcing steel; total cost will be $1750 million. This figure includes all construction and ground support equipment (the heart of the buildings which has not all been installed and/or tested as yet).

Construction work is scheduled to be completed next November but the final testing has already begun and will continue up to the first launch. This will take nearly a year. It is now planned that *Discovery*, the first Vandenberg Shuttle, will roar into polar orbit on 15 October 1985. The mission, designated 1V, is still uncertain. One possibility is a military payload known as DoD 86-IV, another is the Landsat 4 retrieval mission. In the latter case, *Discovery* would be placed into a 560 km orbit, inclined at 98.2 degrees to the equator. This plan faces an uncertain future because of steadily worsening solar cell problems aboard Landsat 4 with final failure considered to be only a matter of time. One problem is that Landsat's orbit must be lowered before the Shuttle can reach it - if it should fail before the manoeuvre is accomplished, retrieval will be impossible. Even if the manoeuvre were successful, the two year delay, before recovery, could leave it too badly damaged to be repaired in space. It then becomes a question of whether the cost of major repairs and launch are justified. Either mission could land back at the Vandenberg AFB runway.

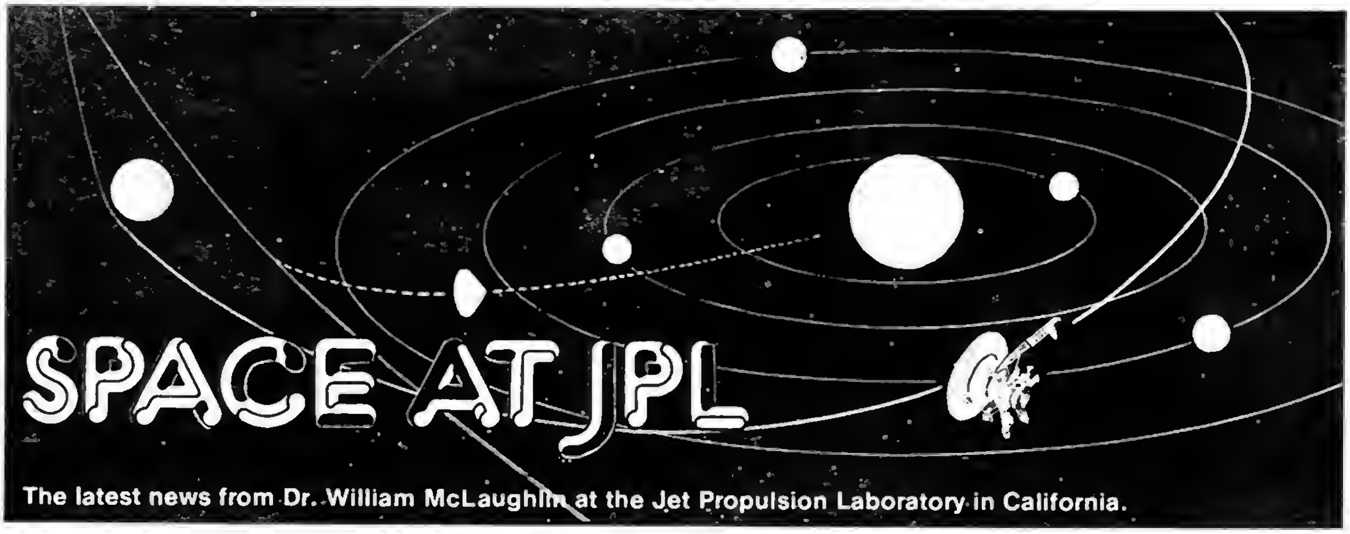
The Vandenberg launch rate is scheduled at four per year by the late 1980's with the capability to build up to 10 per year.

Acknowledgements

A special thanks to the Vandenberg AFB Public Affairs office, in particular 2Lt. Sharon Walker and 2Lt. Mark Hester.



Top: essential elements of the Vandenberg Shuttle launch complex. *Bottom:* a similar area is covered in this photograph. The Shuttle Assembly Building (seen as no. 13 in the top drawing) is not visible here. The Mobile Service Tower at far right provided the viewpoint for the photograph on the facing page.
United States Air Force

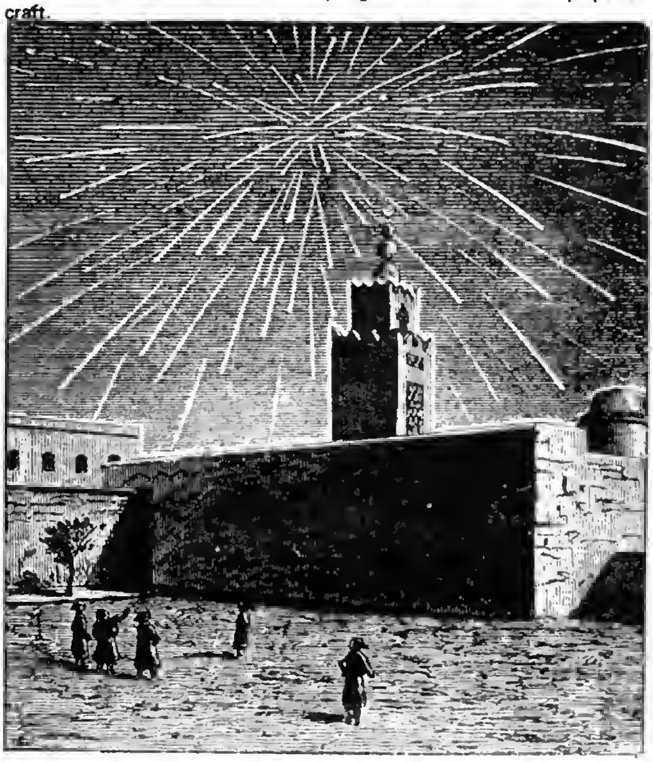


METEOR-STREAM SAMPLING

When the Earth passes through the orbit of a meteor stream one of nature's fine displays can result: witness the annual showers of Lyrid, Perseid and Leonid meteors. The nineteenth century populariser of astronomy, Sir Robert Ball, writes of the spectacular Leonid shower of 1866, "There, for the next two or three hours, we witnessed a spectacle which can never fade from my memory. The shooting stars gradually increased in number until sometimes several were seen at once... Sometimes a meteor appeared to come almost directly toward us, and then its path was so foreshortened that it had hardly any appreciable length, and looked like an ordinary fixed star swelling into brilliancy and then as rapidly vanishing."

Although much has been learned by sampling meteor streams with spaceship Earth, this month's advanced-concept review considers the use of a spacecraft for that purpose. No such mission has been proposed or funded, but some concepts have been developed around which a mission eventually may be structured.

Meteor streams are intercepted by the Earth in its orbit. This process may constitute a precursor for sampling of meteor streams by spacecraft.



The first concept is related to the "atomised sample return" from a comet, which was discussed in last month's "Space at JPL." A large collector on the spacecraft of approximately 100m^2 would be swept through a portion of the orbit of the meteor stream. The collector would be partitioned into small cells, each covered by a thin diaphragm, into which meteors would penetrate, vaporising upon impact and depositing their particulate remnants upon the interior walls of the cells. Upon return to Earth, the chemistry of the stream could be analysed along with information about its density and, possibly, velocity dispersions.

A second concept would use the energy-absorbent properties of crushable styrofoam or similar material to capture meteors in a collector made of this low-density substance. In this way the meteors would be preserved virtually intact for later study; the atomised sample return method destroys crystalline structure. Some testing of this technique has been done in various hypervelocity studies conducted over the last ten years or so (see, for example, a paper by Fechtig *et al.* in "Solid Particles in the Solar System" from the Proceedings of IAU Symposium 90, Ottawa, 1979). A projectile fired into styrofoam at 6 km/s would be brought to rest in less than a metre.

Sampling of more than one stream by a single spacecraft is a mission option, and one JPL study indicates that a dozen or more streams may be intercepted within 10 million km of their central orbit by a single Earth-return spacecraft having a period of 1.5 years.

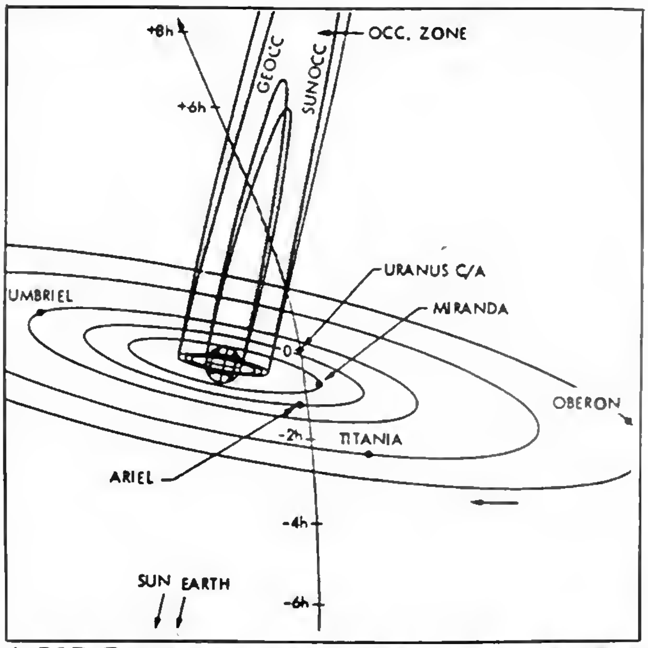
Recovery on return to Earth could be accomplished with spacecraft deboost followed by Shuttle pickup. An alternative recovery mode would be aerocapture or direct entry into the atmosphere with a capsule. In the latter case the large collector would have to be stowed before entry into the atmosphere.

The Infrared Astronomical Satellite (IRAS) found two possible relationships between meteor streams and comets in its discovery of a 30 million km tail on Tempel 2, previously unsuspected debris associated with this comet, and an object of a few kilometres diameter moving in the path of the Geminid meteor stream: possibly a dead nucleus of a comet and the parent body of the Geminids. However, knowlege of meteor stream architecture is at present quite sketchy and a sampling mission would be enhanced in value if more *a priori* data were obtained regarding densities and velocity distributions of the meteors.

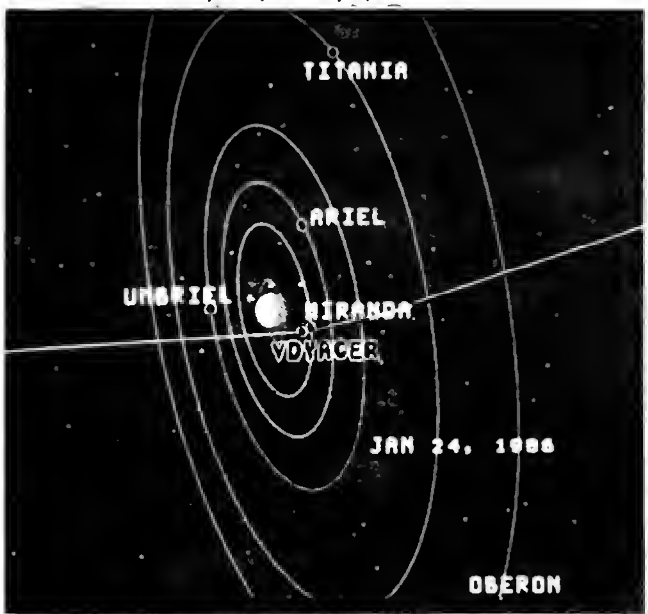
PLANNING FOR MIRANDA

Last month's column examined a few aspects of Voyager 2's work during the almost 4.½ year cruise phase from Saturn to Uranus. The probe will make its closest approach to the planet on 24 January 1986. The exact arrival time will be adjusted (by small midcourse manoeuvres) to obtain the most favourable viewing conditions for Uranus' satellite Miranda. Of the five known satellites of Uranus, Miranda is the smallest, with a diameter of approximately 500 km, and is the only one that will be approached closely by Voyager 2. The plane of the planet and its satellite system is virtually perpendicular to the trajectory of the arriving spacecraft, forming a kind of bullseye target; thus only one satellite can be flown-by closely. There is also a constraint that Voyager 2 has to be targeted to receive the proper gravity assist to enable it to go on to its 1989 appointment with Neptune.

Late last year the Voyager Science Steering Group recommended an arrival time of 18:00 GMT on January 24: a one hour change from the previously-planned arrival time of 19:00 GMT. The change was initiated because Earth-based observations have yielded a better estimate of the position of Miranda at encounter. Thus, in order to achieve a close approach and favourable lighting angles for TV images (near the terminator is the best viewing), the arrival time must be adjusted to match the revised position. Although "closer is better" generally applies to flybys of satellites and planets (for higher resolution) the approach distance to Miranda will be about 29,000 km and not the closest possible range of 15,000 km (which could have been attained with a 16:40 GMT arrival time). The reason for backing off from the nearest flyby is that the rapid, relative angular motion of spacecraft and satellite at 15,000 km would result in smearing of the TV images. Some compensatory slewing motion of the cameras can be done to hold the target steady during the three second exposure time for images, but the procedure is not effective for ranges closer than 29,000 km.



Looking at the Uranus encounter from a viewpoint directly above the plane of Voyager's path. The "GEOCC" and "SUNOCC" refer to Earth and Sun occultation by the planetary system.



Uranus and its system of five known satellites constitute a "bullseye" for the incoming Voyager 2.

FINAL IRAS COVERAGE

By the time that the Infrared Astronomical Satellite (IRAS) had exhausted its liquid helium coolant on 22 November it had used its 300 days in orbit to compile a comprehensive survey of the infrared Universe. Some of the initial scientific results were presented in last month's "Space at JPL," and additional discoveries will continue to be announced for years as the analyses proceed.

The first portion of the all-sky survey lasted from 9 February to 26 August wherein the attempt was made to observe each point of the celestial sphere at least four times. From 26 August to 22 November an additional set of two coverages was being undertaken so that almost each point of sky would have been observed six times had the satellite lasted into January 1984. The actual coverage achieved constitutes a very successful mission and exceeds prelaunch expectations. Although computer processing of sky coverage files is still underway, it is estimated by the Survey Operations Team Chief, Donna Wolff of JPL, that 95% of the sky was covered to "depth four" or more and that 72% was covered to "depth six" or more.

After launch, the prediction was made that IRAS would function until early January of this year based upon the observed rate of helium boil-off. However, it was always recognised that a large uncertainty was built into this estimate due to the restricted accuracy level of the flowmeter which measured the rate of helium and the difficulty in knowing the exact amount of liquid helium loaded into the satellite's dewar container (72.3 kg was the estimate). These factors, plus modelling uncertainties, account for the approximately 10% deviation of estimated from actual lifetime.

IRAS: *ave atque vale.*

JPL IN FICTION

The primary product of the Laboratory's work for NASA is science. Science, ultimately, is incorporated into Society not principally as a material benefit but as a contributor to the manner in which we view the world. Witness the effect of Copernicus' moving Earth (1543) and Hubble's receding galaxies (1920's).

There is a quicker way. Scientific results can pop directly into literature and, with this transformation, exert an immediate influence upon attitudes, circumventing a longer period of incubation. A natural literary venue for

the Laboratory and its lore is science fiction, along with its cousin, space history. Indeed, James Michener's recent novel *Space* features JPL as part of its depiction of the history of the space programme.

But there is truly only one major link between JPL and modern science fiction and his name is Daniel J. Alderson. Dan Alderson is a computing analyst at JPL, and I first met him working on the Viking programme to explore Mars when we collaborated in the development of some computer software. As a derivative from his work for JPL in space, Alderson has served as an unofficial technical adviser to some of today's major writers of science fiction: Larry Niven, Jerry Pornelle, Robert Heinlein, Poul Anderson, and Robert Forward (Forward will also be familiar to Society members through his technical writing in *JBIS*). Recently, Alderson and some associates have formed "Science Fiction Consultants of Hollywood, Inc." to service the television and cinema industries in their development of productions.

Alderson is credited in Niven's *Ringworld Engineers* with contributing to the substantive planetary engineering concepts. In the Niven and Pournelle novel, *The Mote in God's Eve*, he appears as a (long dead) character who invented "the Alderson drive," a faster-than-light population system that made more than the plot move. He is a major character in the Niven and Pournelle novel *Lucifer's Hammer*, appearing as "Dr. Dan Forrester, Member of Technical Staff, JPL" in this story of a comet impacting the Earth. Alderson has appeared as a minor character in several other stories, in recognition of his technical consulting, but played another major fictional role in Poumelle's *Exiles to Glory* a novel of the settling of the asteroid belt. In this work he was cast as "Jacob Norsedal" (the last name being an anagram of "Alderson") and, more importantly, finally lived through the story: a great source of personal comfort.

The publication *Science Digest* has featured in an article hypothetical, large engineering structures such as the well-known Dyson Sphere, Niven's Ringworld and the Alderson Disc. The latter is a massive disc tens of millions of kilometres in diameter and has a large hole in the centre. A captive star has been set in motion perpendicular to the plane of the disc and repeatedly passes through the hole as it bobs back and forth from one side of the disc to the other, tethered in its excursions by the strong gravity of the disc itself. On both sides of the disc live the denizens of this artificial world. Note that, unlike a Dyson Sphere, the Alderson Disc possesses a variety of temperature zones: the warmest being situated adjacent to the central hole.

I asked Alderson if he is working on any new ideas at present. He said yes and described another type of space habitat, "The Alderson Amoeba Plate." But that's another story.

TO CATCH A FAINT SIGNAL

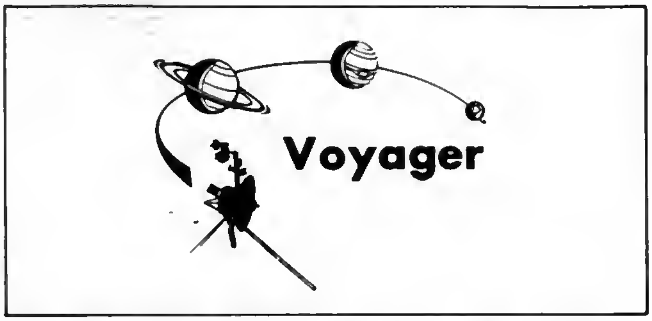
The history of astronomy since Galileo can be seen largely as the attempt to capture more photons: with some additional emphasis in the last 40 years upon gathering photons other than just those of visible light. Thus, optical telescopes have spread their collecting mirrors to an extent of several metres, and radio telescopes can be over 100 m in diameter.

The simple technique of enlarging the diameter of the telescope collector (mirror or antenna) has not reached a limit, with optical telescopes, for example, of 10 m and greater in the planning stages. The Palomar telescope of Caltech has a 5 m mirror.

Recently the technique of combining several smaller collectors to produce, in effect, a larger collector has gained favour for applications in optical and radio astronomy. The Multiple Mirror Telescope (MMT) on Mount Hopkins in Arizona uses six 1.8 m mirrors to create, equivalently, a 4.5 m mirror. A well-known radio complex, the Very Large Array, is located in the state of New Mexico and uses 27 movable 25 m radio telescopes to synthesise a device of great aperture and resolving power. Perhaps the largest array ever envisaged was that of the so-called Cyclops system (never built) which would have linked up to 2500 antennae, each of 100 m diameter in a gigantic electronic orchard in order to search for extraterrestrial intelligence.

The need to collect more photons is not confined to classical astronomy, and the Deep Space Network (DSN) operated by JPL has employed arraying techniques involving electrical coupling to augment the capability of its radio telescopes to track distant spacecraft. For the Voyager 1 and 2 encounters with Saturn, DSN 64 m antennae were arrayed with their 34 m neighbours to allow more data to be returned to Earth than the 64 m and 34 m dishes could have collected separately.

The Voyager 2 encounter with Uranus in January 1986 and distant Neptune in August 1989 makes it even more imperative to bring to bear as much aperture as feasible in support of these events; Uranus is twice as distant as Saturn, reducing received-signal strength by a factor of four. The DSN plans to upgrade the diameter of its three 64 m antennae to 70 m for the Neptune encounter,



although funding approval has yet to be obtained. In conjunction with such an upgrade, improvements on the arraying practice for the Saturn encounter have also been examined. Together, the two approaches would provide a cost-effective way of obtaining increased data return.

The concept of interagency arraying, wherein radio telescopes outside the DSN would be cooperatively employed, is particularly promising. For example, the Australian Parkes 64 m radio telescope will be arrayed with the DSN 64 m antenna in Australia during the Voyager Uranus encounter to achieve a formidable collecting device. Although approximately 300 km from each other, these two radio telescopes will be joined together by a real-time microwave link. In addition to supporting the Voyager encounter, the two telescopes will be available for the 1986 exploration of Halley's comet by ESA's Giotto mission. Outside of tracking distant spacecraft, such a link would also be available for radio astronomy, providing a valuable resource with its 300 km baseline for inteferometric work.

The array of the Australian DSN complex with the Parkes Radio Telescope for Voyager at Uranus is the pathfinder project for interagency arraying and is the first time that this type of support will be provided for a major planetary encounter. Considering the large numbers of radio telescopes in the world, it may presage a new field of international cooperation in telecommunications and science.

SPACE TOURISM: KEY TO THE UNIVERSE?

By David Ashford

Establishing a space tourist industry in the near future might appear at first glance to be somewhat premature. However, the author suggests that such a capability would not only be feasible but would also greatly benefit the 'harder' areas of space activity.

Introduction

The first point is to justify the provocative title of this paper. Why should Space Tourism be the 'Key to the Universe?'

The answer in one sentence is that Space Tourism could well be the first use to justify spending money to develop the really low cost launcher which is the key to further breakthroughs in the use of space.

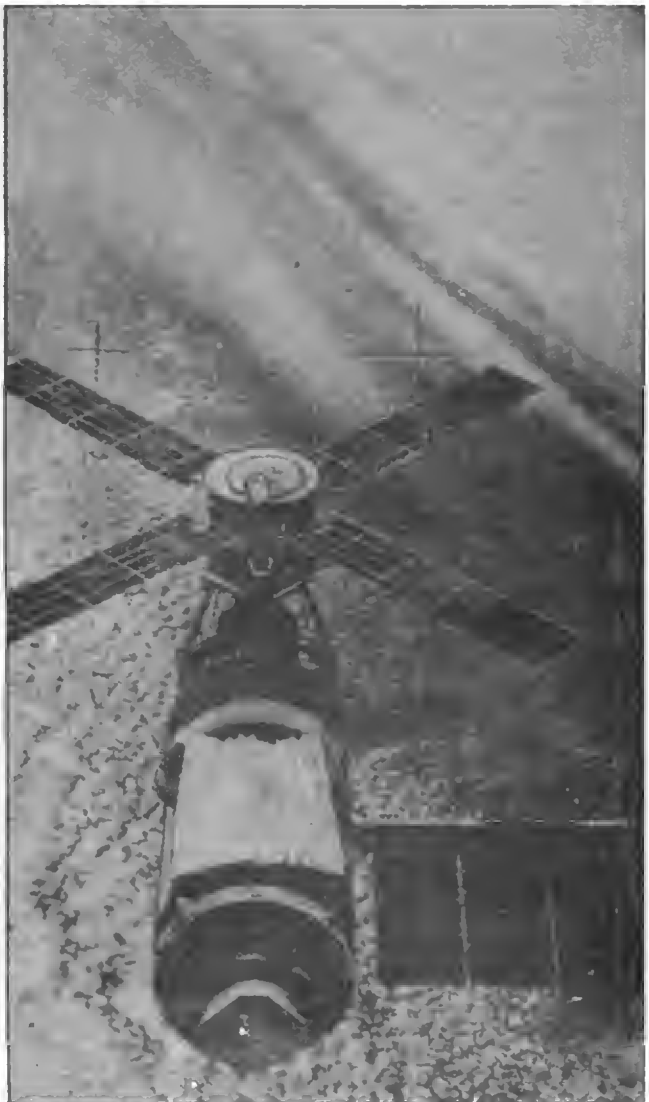
The rest of this paper expands on this sentence and considers the subject in the following order: Launch costs needed for various uses of space; Space Hotels; A launcher for Space Tourism (Spacebus); Spin-offs from Spacebus and Development strategy for Spacebus.

Before starting it should be explained that this paper is a shortened and less technical version of one given to the 18th European Space Symposium, to be published in *JBIS* [1]. However, this paper explores certain aspects in more detail, particularly the design features of Spacebus. (In Ref. 1 Spacebus was called the Target Launcher).

At first sight it might seem that thinking about Space Tourism is an exercise in thinking the unthinkable, which is perhaps why the last serious studies were carried out 15 years ago [2 & 3]. "Tourism is a trivial use of something so serious as space, and the costs are obviously out of this world. What about all the training needed to become an astronaut?" are typical first thoughts. However if one *does* start thinking about it, Space Tourism suddenly becomes surprisingly practical, surprisingly near term, surprisingly big business, and the spin-offs are of potentially enormous benefit to other users of space. The aim of this paper is to stimulate discussion and studies in this direction.

Launch Costs and the Uses of Space

The first thing to be said about space launch costs is that they are still far too high. The NASA Shuttle has a launch cost of about £60 million and a payload capacity of 30 tonnes. The cost per tonne to low orbit is therefore about £2 million. By contrast it costs about £50,000 to charter a Jumbo Jet for a return transatlantic journey, with a 50 tonne payload. The cost per tonne is therefore about £1000, which is three orders of magnitude cheaper than present space launch costs. Shipping costs are even lower. The exotically high cost of space transportation has meant that only missions involving very small mass transportation have become commercially viable. These missions include reconnaissance, communications, meteorology, navigation and Earth resources. In each case satellites weighing only a tonne or so are able to make use of the unique perspective of Earth from space to transmit large quantities of information. It is not stretching the point too far to consider the satellite as part of the transportation system. The goods transported for money (bits of data) weigh so little that a transportation cost of £2 million per tonne can be afforded! These will be referred to as "information" missions.



Skylab was the first US space project that gave its astronauts much time to indulge in leisure activities in orbit. *NASA*

It is quite obvious that missions involving significant mass transfer require a dramatic launch cost reduction before becoming commercially viable. Very few products or services can justify a transportation cost of £2 million per tonne. This raises the question of what cost reductions *are* required for various missions to become self financing. Table 1 shows the results of a preliminary attempt by the author to answer this question.

As already mentioned, information missions are commercially viable in spite of launch costs as high as £10^6 per tonne. While these missions would clearly benefit from lower costs there appears to be no crying need for dramatic improvement.

The next three missions on the list are Space Tourism, Space Manufacture and Military (excluding military missions which are in the "information" category). These are called near term mass missions because they involve significant mass transfer and could become viable in the next decade or so.

Considering space tourism, the first question to ask is how much people would be prepared to pay for a holiday in space. There is little doubt that a space hotel would provide a fascinating and unique experience, and would be considered as a very upmarket holiday. (This subject is considered further in the next section).

Without doing a market survey it is difficult to answer the question with any certainty. However, it seems reasonable to assume that significant numbers of people

would pay £10,000 for a few days in space and that large numbers would pay £1000. For present purposes let us assume an intermediate figure of £5000, of which £3000 is available for transportation to and from orbit. The average space tourist, together with the very limited baggage and the consumables he/she will need for a few days, will probably weigh about 100 kg. The required transportation cost is therefore about £30,000 per tonne, which is two orders of magnitude cheaper than today's cost.

This example is clearly somewhat speculative but we can conclude that a launch cost reduction of about two orders of magnitude is required for space tourism to begin to become self financing.

Considering the other two near term mass missions (space manufacture and military) very little has been published to form the basis of a market survey. However, by intuition and analogy with the early exploitation of aircraft it seems probable that these missions require a launcher of generally similar technology and cost levels to space tourism. The first passenger transport aircraft (analogous to space tourism) and air mail aircraft (analogous to transporting space manufactured products) were converted World War I bombers.

A further order of magnitude reduction (to bring launch costs in line with present air transport costs) is probably needed for "everyday" space missions, such as sub-orbital transport, solar power, mining and colonisation.

The main conclusion from this brief survey of launch costs is that a launcher of much reduced cost (about two orders of magnitude) is needed before new uses of space can become self financing.

Launchers with such costs are technically feasible (as discussed later in this paper), and the problem is to find the funding for their development. Let us therefore consider the various missions to see which are most likely to generate the required funding. The way ahead for launchers of "information" satellites is reasonably clear, at least in broad terms. Developments of Ariane and Shuttle are proposed which will satisfy the requirements for information missions for the next decade or two. However, these developments are aimed more at increased capacity than at reduced cost. Moreover the requirements for information satellites (unmanned, mostly geostationary orbit) are different than for the mass missions, which all require manned payloads to low orbit. Thus it is likely to be several decades before launchers designed for information missions evolve to a stage where derivatives are economical enough for mass missions.

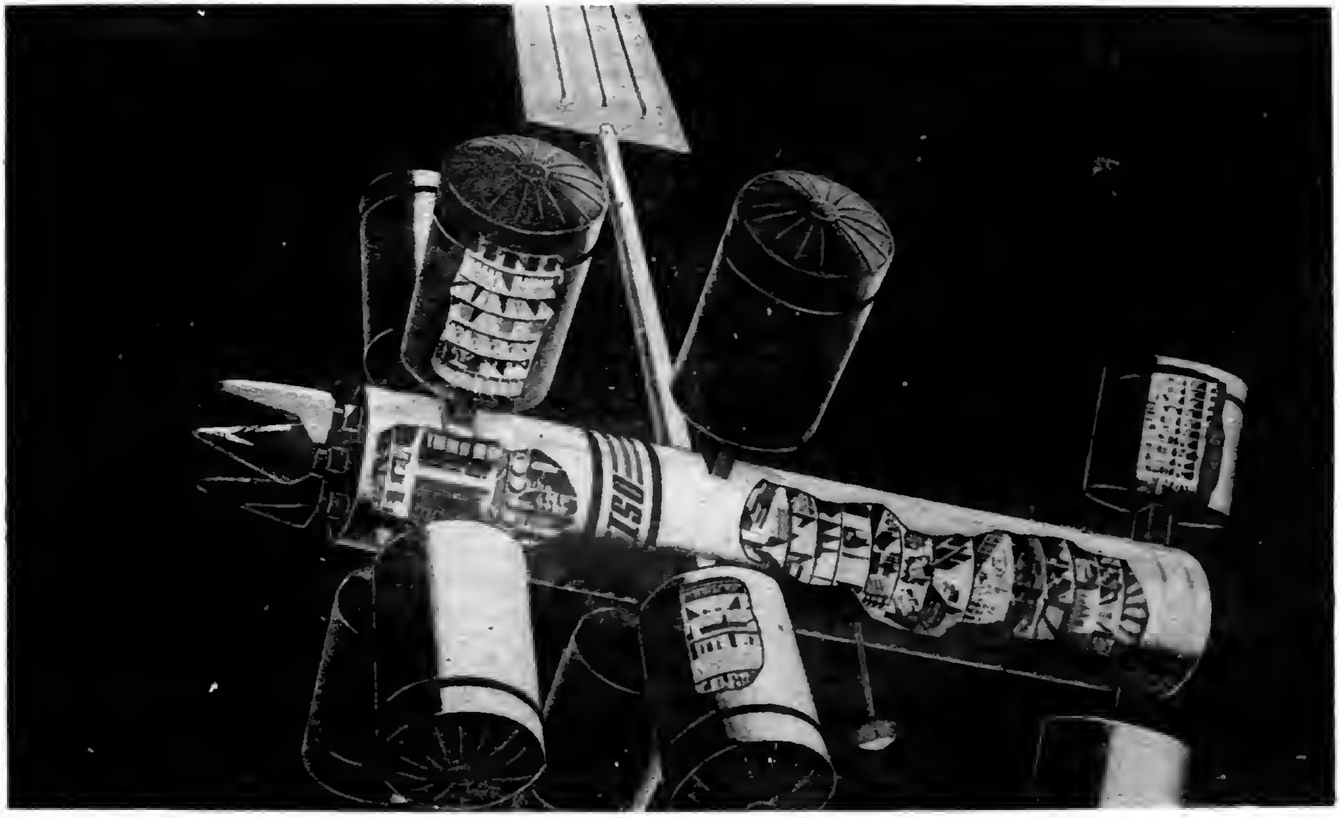
The far term mass missions (sub-orbital transport, solar power, mining and colonisation) are of great interest but are too far into the future for taxpayers to be persuaded to spend large sums of money on them today.

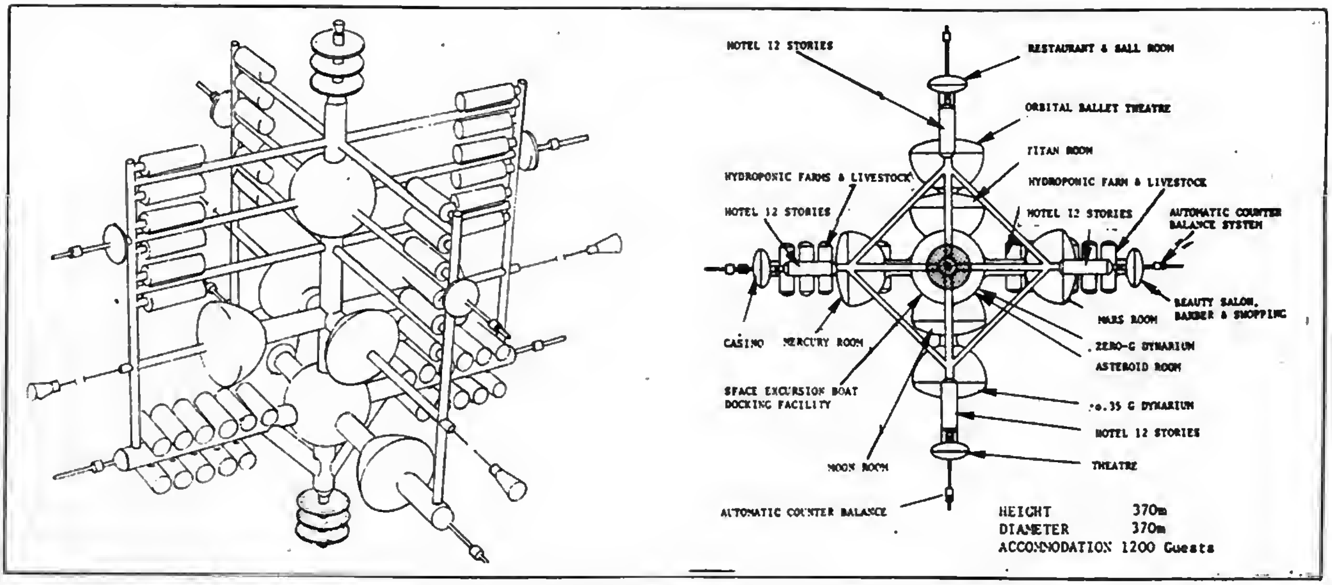
This leaves the near term mass missions, i.e. tourism, manufacture and military uses. All three missions require a launcher of Shuttle size or smaller. Space Tourism

Table 1. Launch cost needed for self-financing space missions.

Mission		Required Launch Cost to Low Orbit, £/Tonne
Reconnaissance Communications Meteorology Navigation Earth Resources	Information Missions	£10^6
Tourism Manufacture Military	Mass Missions (Near Term)	£10^4
Sub-Orbital Transport Solar Power Mining Colonisation	Mass Missions (Far Term)	£10^3

A large space station could provide its occupants with a whole host of activities impossible back on Earth. (This is an early large station concept not to be taken as representation of the author's suggestions.)





Orbital tourist facility. *Left:* overall view. *right:* top view. The bell-shaped objects in the overall view are power supplies (From Ref. 3).

requires a two orders of magnitude cost reduction and the other two missions would clearly benefit from such. The short-term way ahead for space manufacture and military uses is to use the NASA Shuttle for experimental work and pilot schemes. At present there are no plans to promote space tourism, although the NASA Shuttle could be used for very early development. Any of these three missions could suddenly take off and generate the interest needed to fund a new launcher.

Of the three, space tourism could well become the driver for the development of a new launcher, for two reasons.

Firstly, tourism is a big business and the attractions of a space holiday are obvious. Present day annual expenditure on long haul (>2800 km) tourism from Europe and North America is no less than £10,000 million. If only 5% of this expenditure were diverted to space tourism, the annual payload to orbit would be about ten thousand tonnes, which is two orders of magnitude higher than the present annual tonnage to orbit.

The second reason is more subtle and speculative. So far space has been very much an élite business with taxpayers as (generally willing) spectators. In spite of achievements like the lunar landing, the NASA Shuttle, Ariane and planetary close ups and innumerable space fiction series on film and TV, the thought that he might actually be able to visit space has not crossed the imagination threshold of Mr. or Mrs. Average (readers of *Spaceflight* excepted!). If presented with a well planned and credible investment programme (public or private sector) leading to a space tourism industry which he could use, the response from the average taxpayer (or investor) could be very enthusiastic. The thought of participation could generate a new wave of taxpayer support for space activities.

To summarise this brief look at launch costs and the uses of space it appears that a launcher with much reduced cost is needed for new space missions, that tourism could be the earliest and largest user of such a launcher and that space tourism could generate renewed public interest in space activities.

Space Hotels

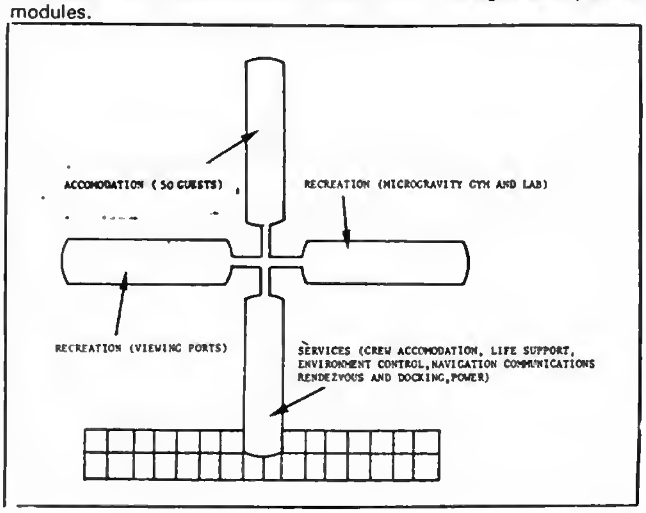
A surprising aspect of space hotels is that the most recent studies were carried out as far back as 1967 [2 & 3], at least according to a recent literature search. (If any reader can point out a more recent study, the author would be grateful to hear of it). This paper, therefore, will do little more than recap some of the main features of the 1967 studies, and point out how recent developments, particularly Shuttle and Spacelab, could be exploited. The basic features of an early space hotel are fairly obvious — accommodation for a few tens of visitors for a few days, a microgravity gymnasium, and viewing ports for looking at Earth, Sun, Moon, planets and outer space. Beyond that it becomes an exercise in creative imagination.

Spaceflight readers are probably more concerned with the "when" and "how" of space tourism than with the "what."

Even 15 years later these designs illustrated from Ref. 3 are futuristic and it is worth considering less ambitious interim schemes. The easiest way to start would be to use the NASA Shuttle itself. It would be straightforward to re-configure the cargo bay to accommodate around 10–20 tourists for up to a week. However, at a cost of £60 million per launch a fairly hefty subsidy would be needed! Moreover the acceleration levels during launch require a fair degree of passenger fitness and the recreation facilities would be limited.

The next step would be a hotel based on Spacelab and Shuttle hardware. It is quite surprising how complete a hotel could be built with existing hardware or derivatives. A very tentative concept sketch is included below. The

Interim Space Hotel. Preliminary concept with four lengthened Spacelab modules.



POSSIBLE ORBITAL TOURIST FACILITIES [3].

- Large low-g or null-g "Dynaria" in which the vacationers can "swim" i.e. move about in three dimensions, like fish in water. Instead of water currents, air streams are circulated.
- Dynaria also serve as space theatres showing ballet and acrobatics under low-g conditions; and as sports stadium for competitive games such as three dimensional tennis.
- Earth and Space Observation Rooms.
- Small laboratories in which guests can be shown, or can conduct themselves, interesting and entertaining experiments under low-g or null-g conditions.
- World-Rooms, large volumes simulating realistically landscapes, illumination, thermal, atmospheric and gravitational conditions on the surface of other celestial bodies or of planetary worlds.
- Space Zoo and Botanic Exhibitions, showing animals and plants from other Worlds or from Earth, changed by generations of existence under low-g conditions, mutants by radiation or reared under different combinations of g-level, atmospheric pressure and composition and temperatures.
- Video telephone service through which guests can contact friends and relatives on Earth when passing over their areas.
- Space Walks on (or without?) tethers.
- Space Boats, rented for tours around the large Tourist Facility or for brief orbital excursions.

basic building block is the Spacelab module lengthened to take up the entire Shuttle cargo bay. Four such modules are used in the design shown, connected by tunnels. One is for accommodation, two for recreation and one for services. Each module has a length of 16 m, a diameter of 4 m and a volume of 200 m^3. If we assume 4 m^3 per person (which is typical for a 4-berth caravan) then the accommodation module will house 50 tourists. Power is provided by the 25 kW Power Module being developed by NASA. Life support systems, attitude control systems, navigation systems and communications systems are derived from those in Shuttle and Spacelab. Clearly, significant development work would be required for a space hotel to become a reality, but in broad brush concept terms it is clear that a useful hotel could be built from existing hardware or derivatives.

A similar building block approach is being adopted for the proposed NASA programme for Space Platforms (as described in *Spaceflight*, April 1983) which will clearly have much in common with an early space hotel. Equally clearly, the case for the Space Platforms is strengthened by the case for space tourism and *vice versa* since a large part of the development costs can be shared. With a potential market of tens of thousands of tonnes per year (as dicussed in the previous section) Space Tourism could well become the largest user for such an orbital facility.

Given the virtual availability of the hardware for a space hotel and the large potential demand, it is surprising that the most recent feasibility study was carried out 15 years ago!

Launchers

Two types of launchers are needed for space tourism. Firstly a vehicle to launch the hotel to low orbit and, secondly, a vehicle to transport the tourists, crew and consumables. The requirements for these launchers are very different. The first requires a large payload (at least the 30 tonnes of the NASA Shuttle and preferably larger), need not be man rated, need not be comfortable enough for passenger use, and is only used once per hotel module. The second needs a smaller payload (say 3 tonnes for 30 passengers and supporting cargo), needs to be safe and comfortable enough for granny, and needs to be designed for rapid turnaround and frequent flights.

Perhaps the biggest difference is the cost requirement. We have already seen that a transporter for launching space tourists requires a cost per launch as low as £30,000 per tonne. To find the cost requirement for the hotel launcher let us make some simple assumptions:

1. Transportation costs of hotel itself not to add more than 20% to tourist fare.
2. Hotel life is 10 years.
3. The average visit length is 3 days (say 100 visitors per 'place' each year).
4. The hotel mass is five times that of the tourists it can carry.

If the fare per tourist is £5000 then the toal revenue in 10 years from one passenger place is £5000 x 10 years x 100 visitors per year, or £5 million.

The required launch cost per place is therefore no more than £1,000,000 (20% of £5 million). The mass per place is 500 kg (5 times the 100 kg mass per passenger) and so the required launch cost is £1,000,000 per 500 kg, or £2 million per tonne, which is about that of the Shuttle.

Put another way, the hotel handles 200 times its own weight during its ten year life. The cost of the re-supply missions (i.e. carrying the tourists, crew and consumables) therefore dominates the cost of launching the hotel in the first place.

This leads to the somewhat surprising conclusion that present day launchers are adequate in all respects for launching space hotels, although lower costs would obviously help.

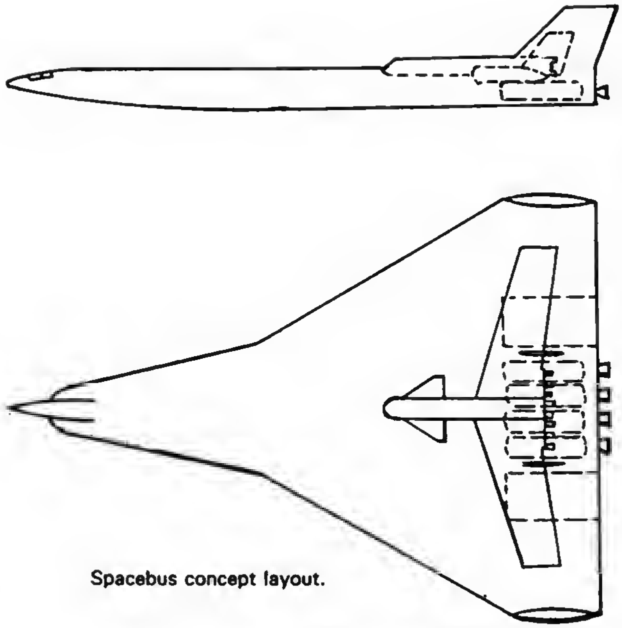
The launcher for transporting the tourists is another matter. The NASA Shuttle is the best available at present. However, the following improvements or changes are clearly necessary.

1. Lower costs. If we assume that of the £5000 fare, £3000 is available for the launch phase then the revenue per Shuttle flight would be £3000 x 70* passengers = £200,000. This compares with the present Shuttle launch cost of about £60 million.
   (The required reduction on this basis is greater than the two orders of magnitude mentioned earlier because the Shuttle is volume limited rather than mass limited for passenger carrying).
2. Fully reusable. For high frequency operations the Shuttle's habit of dropping tanks and engines in the sea is not acceptable environmentally, apart from cost considerations.
3. More comfortable. Vertical take-off and a peak boost acceleration of just over 3g will put off a large number of potential space tourists. This implies that horizontal take-off and more gentle accelerations during the launch phase will be necessary.
4. Airworthiness. A launcher carrying passengers

* *A projected passenger version of the Shuttle has 70 seats.*

Table 2. Main Spacebus data.

Booster		
	Span, m	56
	Length, m	78
	Engines	Turbojet to M=2 (8 x Olympus?) Rocket to M=4 (4 x Ariane 2nd Stage)
	Separation Speed	M=4
	Weight, Tonnes	
	Empty	130 (37% AUW (cf 43% for Concorde)
	Payload	100 (Orbiter)
	Fuel	120 (42T to M = 2, 68T to M = 4, 10T for Return)
	All-up	350
Orbiter		
	Span, m	46 m
	Length, m	22
	Engines	4 x quad HM7 (from Ariane 3rd Stage)
	Weight, Tonnes	
	Tankage	6.3 (8% Fuel, cf 5.5% for NASA Orbiter ET) 3.0 (Thrust/Weight = 1, Mass/Weight = 3%)
	Structure, Systems, Margins, unused fuel	8.6 (Typical weight empty for 30 seat airliner)
	Payload	3.0 (30 pasengers)
	Fuel	79.1
	All-up	100.0 Tonnes


Spacebus concept layout.

on a regular basis will need to be designed and certificated to British Civil Airworthiness Requirements, or equivalent, which are tougher than the present requirements for manned space flight.

There have been literally dozens of feasibility studies over the past 20 years of launchers which meet these requirements, or come close to so doing. In fact launchers probably hold the record (compared with any other type of vehicle) for the highest ratio of projects studied to built!

Possibly the closest to the tourism requirements were some of the Eurospace Aerospace Transporter studies of the early 1960's [5].

The diagram shows a concept sketch of a launcher intended to meet the requirements *at minimum development cost and risk*. It is an update of work carried out by the author in 1965 [4] taking account of developments since then.

The design has been called "Spacebus" to denote its primary purpose of carrying fare-paying passengers. Compared with previous designs for two stage reusable launchers the Spacebus concept has generous design margins. These reduce development risk and increase growth potential. The penalty is an oversized vehicle for the initial design payload. However, in the first few years of Space Tourism, development cost will predominate and there will be a rapid growth of opportunities. Low development risk and adequate growth potential are therefore more important than low nominal operating cost in the early years.

The Booster stage is a large supersonic aeroplane, weighing twice that of Concorde. It has turbojet engines for takeoff, acceleration to Mach 2 and flyback and landing. Four Ariane rocket second stages are buried in the aft fuselage. These provide acceleration to the separation speed of Mach 4, which occurs at the top of a semi-ballistic climb to a height where dynamic pressure is very low (to reduce air loads on the Orbiter stage and heating loads on the Booster). The Orbiter stage consists of a convential airliner fuselage with a capacity of 30 passengers. The Liquid Oxygen/Liquid Hydrogen propellant is carried in a large thick pressure stabilised wing. The engines are four quadruple HM7 motors, from the Ariane third stage.

In order to achieve the required design margins and low development risks, Spacebus incorporates the following features:

1. *Booster Turbo Jets*
The maximum air-brething speed of Mach 2 means that an off-the-shelf engine installation can be used. The present limit to airbreathing engines is about Mach 4, but such a speed would require an expensive engine installation (intakes and nozzles) development programme and would increase the Booster thermal loads. This extra Mach 2 is a margin in hand for later development.

2. *Booster Rockets*
To simplify development, the booster has four complete Ariane second stage units requiring only minor modifications. A more efficient design could be obtained by integrating the tanks with the Booster structure and by halving the tank size to carry the required propellant mass. This spare volume represents another margin for growth.

3. *Booster Stability and Control*
For a boost vehicle, aerodynamic efficiency in the conventional sense (specific fuel consumption x lift: drag ratio) is not particularly important. The aerodynamic design can therefore be optimised for a large stability and control margin (allowing higher Booster speeds and a variety of upper stages to be carried without re-design), and a good airfield performance.

4. *Booster Payload Accommodation*
The booster is fitted with a shroud to protect the Orbiter from airloads during the boost phase. The boost phase is therefore not a design case for the Orbiter. As previously mentioned, the boost phase trajectory is such that separation takes place at low dynamic pressure. Separation loads should therefore be low.

5. *Orbiter Tank Design*
The Orbiter propellant dominates the design from the point of view of both mass and volume,

therefore critical. The Spacebus concept of configuring the tanks as a separate thick wing is a solution which offers a low wing loading, thereby reducing air loads and thermal loads. The landing gear, controls, engines and fins have been kept as inboard as practical. The outboard sections of the tanks are therefore free from all loads except airloads, inertia loads, and thermal loads, and can be designed as a "pure" structure free from cutouts and local reinforcements.

To date, only very preliminary sizing calculations have been done on Spacebus, and no cost estimates. However, assuming that a reasonably long life can be achieved there is no reason why the cost per launch should be much more than that of an aeroplane of similar size. Thus the Booster weighs about twice as much as Concorde, which has a cost per flight of around £40,000. A realistic cost per flight target for the booster might be around £100,000. The Orbiter is much smaller but has a worse re-entry environment, and all-rocket propulsion making a long life more difficult to achieve. If we assume that these factors cancel out, then the cost per flight of the Orbiter should also be around £100,000, once well down the maintenance and operating learning curves. The cost per seat (30 seats total) is therefore around £7000. This is more than the figure assumed earlier of £3000 but is nonetheless two orders of magnitude cheaper than Shuttle. A Mark II version of Spacebus, using up some of the margins to give a separation speed of M=6, could carry twice the payload, reducing the cost per seat to around £3500.

Spin-Offs

A launcher capable of carrying 30 passengers or 3 tonnes of cargo with a cost per flight of around £200,000 would greatly reduce the cost of virtually all space operations. For military purposes the benefits of a low cost per flight are obvious. For space manufacture the production of much lower value products would become viable. Spacebus would considerably reduce the operating cost of any space station by reducing the logistic support costs. For any long-life space station the transportation cost of logistic support (spares, mechanics for repairs, consumables, crew change, return of samples, etc.) will be very high using Shuttle or Ariane. Compared with other missions, Space Tourism probably has the highest ratio of support transportation cost to initial launch cost, because a Space Hotel, as mentioned earlier, handles hundreds of times its own mass during its lifetime. (Which is one reason why Space Tourism could be the first mission to require a launcher like Spacebus).

For information satellites to geostationary orbit the benefits are less obvious but nonetheless significant. Firstly, small satellites could be transported to low orbit in Spacebus at much less cost then in Shuttle or Ariane. Secondly, the fuel for reusable Orbital Tranfer Vehicles could also be carried to low orbit in Spacebus. Thirdly, for larger satellites which require Shuttle or Ariane, in-orbit assembly and checkout are attractive possibilities. The ability to send up mechanics at low cost means that failures in the automatic assembly process can be tolerated.

Fourthly, a cargo version of the Mark II Spacebus with an expendable upper stage could launch a satellite of about 10–15 tonnes to low orbit, which is close to the provisional requirement for the new ESA launcher. The cost per launch would be significantly less than that of a rocket launcher, even if reusable, because of the greater robustness and longer life of an aeroplane-like first stage.

In summary, a launcher like Spacebus is essential for a viable tourist industry but will greatly benefit nearly all other space activities by offering a two orders of magnitude cost reduction for small and medium sized payloads.

Development Strategy

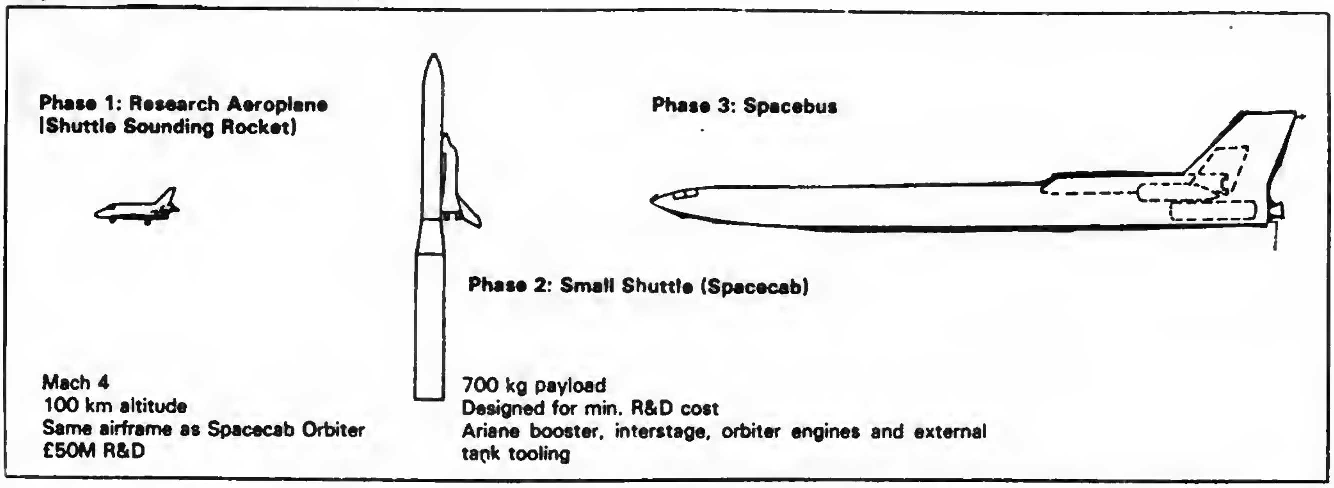
Spacebus has sufficiently low risk that it could be designed and developed starting now. However the R&D cost would be high and the case for investing hundreds (or thousands) of £ million now in space tourism is not overwhelming. However, a progressive development sequence of less advanced launchers can be derived leading step by step to Spacebus. One such programme is shown in the diagram. The first vehicle in the sequence is a rocket powered research aircraft with a development cost of only £50 million. This leads directly to a small shuttle (Spacecab) which would be a useful complement to present and planned launchers. The main purpose of Spacecab is the logistic support of space platforms. The successful development of Spacecab and these platforms would pave the way for Spacebus and Space Hotels.

Conclusions

This survey of Space Tourism has of necessity been carried out at preliminary concept level only. Nonetheless, the following conclusions can be derived with confidence.

1. Space Tourism could be very big business.
2. The hardware for a first generation space hotel

Phased development programme for Spacebus.



Viewing the Earth will provide one of the most fascinating aspects of space tourism. ESA

(more or less) exists from Spacelab and Shuttle.

3. Existing launchers are economical enough for launching the Space Hotel, because the hotel handles many times its own mass during its years in orbit and the initial launch cost becomes a small part of the total.
4. For carrying the passengers to and from the hotel a new launcher is needed, with a cost per tonne to low orbit about two orders of magnitude less than the NASA Shuttle.
5. The technology for such a launcher exists and Space Tourism could well be the first use to justify its development.
6. Such a launcher would greatly benefit nearly all space missions.
7. Given such a launcher, Space Tourism could be the larget user of space transportaion in terms of tonnes per year, (although this honour could well be shared with space manufacturing). Even if only a few per cent of present day tourists were to take a space holiday, the annual payload to orbit would be measured in tens of thousands of tonnes.
8. A low-cost, low-risk stepping stone approach to developing the new launcher has many advantages, with a small shuttle as a very useful interim launcher.
9. Further study seems to be well justified, particularly in the following areas:
   - Market survey for Space Tourism.
   - Feasibility study of Space Hotel using Spacelab and Shuttle hardware.
   - Feasibility study of new launcher.
   - Feasibility study of interim launchers.
   - Other uses and benefits of a low cost launcher.

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CHALLENGER'S RETURN TO SPACE

By John Pfannerstill

The concluding instalment on the seventh Shuttle mission follows the SPAS free-flying pallet operations and *Challenger's* return to Earth.

Mission Day 4

The astronauts' fourth day in space began at 05:39 on 21 June with the wake-up call from MCC-H. Almost immediately, the astronauts notified Houston that the SPAS was overheating. The pallet satellite had been left running to gather data during the crew's sleep period, and this extra run time had apparently caused some of the instrumentation to become too hot. MCC-H and the crew decided to shut the SPAS down to allow it to cool off.

Eventually, MCC-H decided to leave the SPAS shut down for the entire day. The overheating problem could potentially jeopardise the free-flight operations with the pallet satellite. Since that was a major goal of the STS-7 mission, no one wanted to take any chances.

This decision made Day 4 a rather light work day for the astronauts. Crippen and Hauck fussed over some malfunctioning wireless headsets, Dr. Thagard continued his motion sickness investigations and, now having nothing to do, Fabian assisted Ride with her major tasks for the day, the operation of the CFES.

Beginning at about 08:15, Ride ran the CFES for about six hours. During this time, three samples were processed by the McDonnell Douglas unit. During a live TV broadcast from the middeck, Ride described the CFES itself and the work she was doing. Complimenting her on the lucid description, capcom astronaut Terry ("T.J.") Hart told her: "You'd make an excellent tour guide of science on the Shuttle."

"Isn't science wonderful?" she replied.

In other activities, Crippen and Hauck successfully raised the cabin pressure back up to 760 mm Hg after the planned 30 hours at 527 mm. The test was a success in that the pressure held well at the lower level with only minimal manual adjustments.

Mission Day 5

Day 5 was to be the most challenging and exciting day. Ten hours were allocated in the flight plan for "Proximity Operations" (or "Prox Ops"), which would consist of the crew's twice releasing the SPAS into space, manoeuvring *Challenger* first away from and then back toward it, before finally retrieving the pallet satellite once again for return to Earth.

The exercise would provide several "firsts" for the Space Shuttle programme. Among them:

1. First release of a payload from the RMS arm. Previous payloads on STS-3 and STS-4 had been lifted out of the payload bay by the arm and moved about, but none had ever been released.

2. First demonstration of the Shuttle Orbiter's station-keeping and manoeuvring capability in close proximity to another orbiting spacecraft. This was particularly important in preparation for STS-13's upcoming rendezvous with and repair of the ailing Solar Maximum Mission satellite [7].

3. First demonstration of the Orbiter's Ku-band Rendezvous Radar system, which is used to obtain range and range rate data with respect to another vehicle.

4. First retrieval of a free-flying spacecraft using the RMS arm.

America's first space woman, Sally Ride.

On a more aesthetic line, the operation would also provide the first views of a Shuttle Orbiter from another spacecraft. The SPAS carried both colour and black and white TV cameras to provide real-time views of *Challenger* in space, as well as 70 mm still and 16 mm motion picture cameras loaded with colour film to provide even sharper, more spectacular images once the SPAS was returned to Earth.

As the crew prepared for the Prox Ops exercise, the SPAS overheating problem again became a concern. Engineers in MCC-H had set 102°C as the limit. If the temperature went above that, the operation would have to be at least curtailed if not cancelled altogether. Crippen noted with concern that in the first hour after powerup, the SPAS temperature had been steadily rising. Nevertheless, the crew proceeded through a successful checkout of the pallet satellite.

Following the checkout, Fabian uncradled the RMS and grappled the SPAS. Then, after retracting the SPAS umbilical, he used the arm to lift the 2280 kg pallet

satellite out of the bay. Fabian raised the SPAS high over the Orbiter and, after receiving a GO from MCC-H, he performed a quick release and re-grapple of the payload to assure himself that all the end effector mechanisms on the arm were working properly. Although the SPAS was only flying free less than 60 seconds, it nevertheless marked the first time that a payload had ever been actually deployed and retrieved by the arm.

By 08:10, after the SPAS was back on the arm, the crew noted that its temperature had risen to 99.4 degrees, very close to the limit. MCC-H watched the temperature rise to 101 over the next few minutes. In a very tight decision, they gave the crew a GO for release and separation, a decision that was met by sighs of relief aboard *Challenger.*

The SPAS was released at about 08:50 as the Orbiter passed over the United States on Orbit 63. The pallet's nitrogen gas thrusters kept it very stable.

"My compliments to the people from MBB," Crippen said, "That SPAS is a nice-flying little vehicle."

At a separation rate of about 0.08 m/s Crippen manoeuvred *Challenger* down and away from the SPAS. He let the Orbiter drift slowly beneath and then ahead of the pallet until it was 305 m behind him. That was as far away as plans called him to go.

After the Orbiter reached the 305 m range, Ride commanded the SPAS into a free-drift mode, shutting off the pallet's attitude control system. While *Challenger* held at that distance, the SPAS' MAUS-2 materials processing experiment was run for about two hours. The data from MAUS-2 would be compared with that obtained with the identical MAUS-1 investigation, which was performed with the SPAS berthed in the payload bay. These and other tests, including a rendezvous radar evaluation, were done during the two hours *Challenger* and the SPAS spent at maximum separation from each other.

The television views were spectacular. The colour television camera on the SPAS worked incredibly well. *Challenger* was clearly visible, gliding silently over the deep blue, cloud-dappled Earth, its open payload bay facing directly at the pallet's camera. Viewers could easily see the payload bay contents, the two closed Sunshields that once covered Palapa and Anik, the OSTA-2 pallet, the seven small GAS canisters, and the RMS arm, which the crew had purposely left cocked into the shape of the numeral "7" to symbolise their mission.

There were lots of 'oohs and aahs' in Mission Control as the stunning pictures appeared on the screens. "Beautiful, that's beautiful!" said capcom Jon McBride upon his first view, "Another space first!"

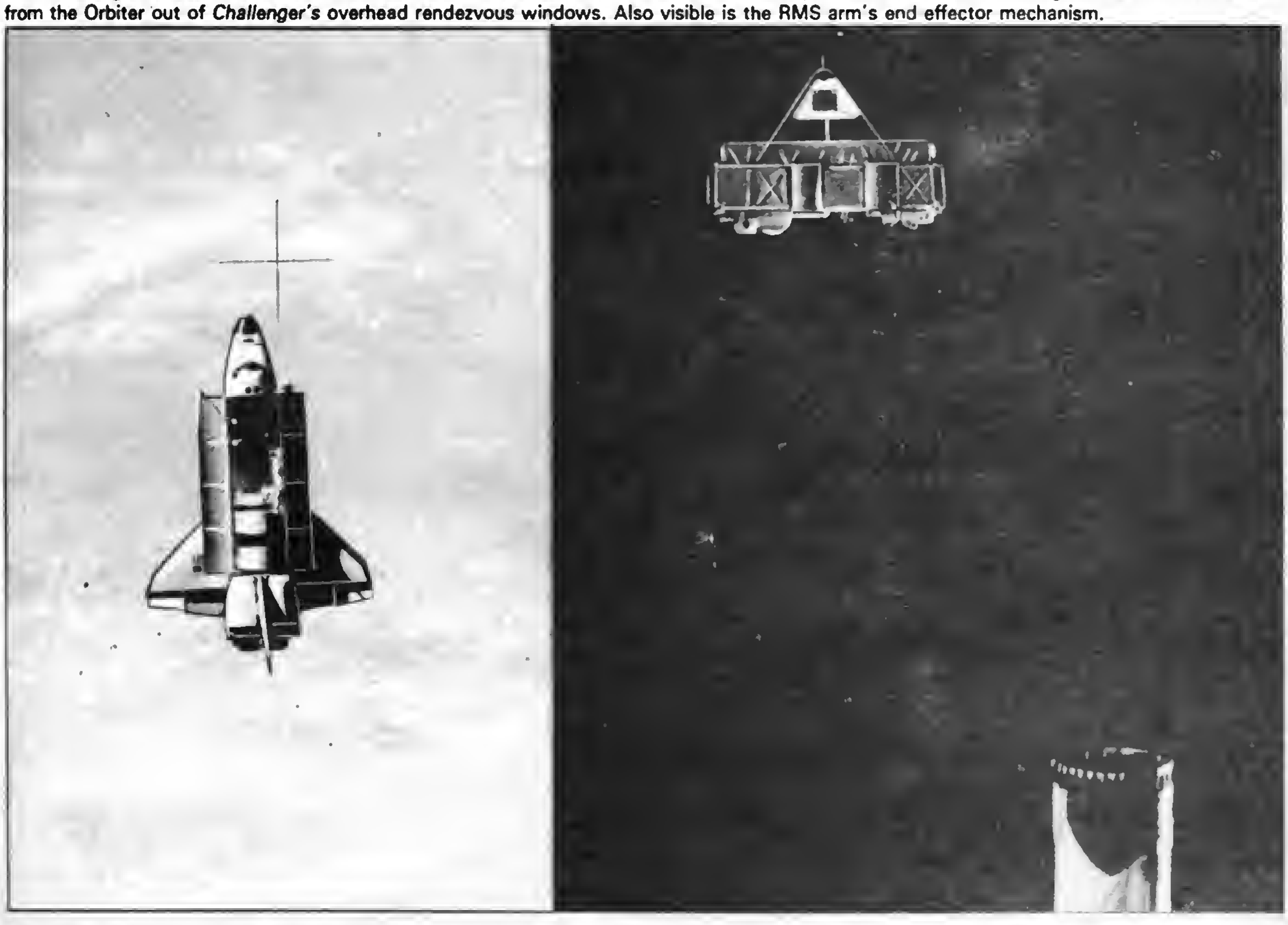
At 10:55, Ride commanded the SPAS out of the free-drift attitude mode, and shortly thereafter, Crippen began moving *Challenger* back toward the satellite. Of prime importance during the closing operations was an evaluation of the Orbiter's ability to manoeevre close to another spacecraft without letting the powerful RCS thruster plumes disturb the vehicle being approached.

A thruster setup called "Low-Z Mode" was employed when the Orbiter had closed to within 60 m. Low-Z used only those RCS jets that did not fire directly at the pallet. Slowing *Challenger* down relative to the SPAS in this way required 12 times as much propellant, but the satellite remained undisturbed by the Orbiter's manoeuvres.

By 12:25, as the Orbiter passed over the Ascension Island station on Orbit 65, Fabian reported: "We have the SPAS back on the arm." The first phase of Prox Ops went extremely well. Crippen was tremendously impressed with *Challenger's* manoeuvrability.

Before quitting for lunch, the flight plan called for one more practice release and capture. After release, Ride

Left: Challenger **as seen from the SPAS when the two vehicles were at their maximum separation of about 300 m.** ***Right:*** The SPAS as viewed from the Orbiter out of ***Challenger's*** overhead rendezvous windows. Also visible is the RMS arm's end effector mechanism.



commanded the SPAS into a 0.1 degree per second rotation. This forced the astronaut operating the RMS to continuously move the arm to track the pallet as he approached for capture. Since he had had very little to do during the morning's activities and because earlier in his astronaut training he had helped develop RMS operating procedures, Crippen exercised his perogative as commander and let Dr. Thagard perform the rotating SPAS capture. The test went very well, and at 12:43, with the pallet perched on the end of the arm, the crew took a lunch break.

Throughout the morning, MCC-H and the astronauts closely monitored the SPAS' temperature. By the time it was shut down for the crew's meal period, the temperature had risen to 108 degrees. Before beginning the afternoon Prox Ops activity, MCC-H decided to extend the planned one hour break to 2.5 hours to give the SPAS more time to cool down. In addition, *Challenger* was manoeuvred in such a way that it would shade the pallet to speed the cooling process.

When the crew powered the SPAS back up at 14:20, its temperature was down to 73 degrees. By 15:00 hours the SPAS was again flying on its own.

For the afternoon session, the crewmembers reversed the roles they had taken in the morning. Crippen took up Hauck's morning job of monitoring Orbiter systems so that his second in command could have a chance to fly *Challenger*. Likewise, Ride and Fabian traded places, with Fabian taking Ride's morning task of commanding the SPAS so that America's first space woman could operate the RMS.

This time, the plan called for something entirely different. As Hauck backed *Challenger* away from the SPAS, he stopped it momentarily at distances of 21, 31 and 61 m. Each time, he intentionally fired the RCS thrusters in the direction of the SPAS to see what effect the direct blasts would have on the pallet. At 31 m, the television views clearly showed the satellite being buffeted. At times, it rolled as much as 90 degrees. The vehicle was built to withstand such a beating however, and it came through the tests with no ill effects. Crippen told MCC-H: "It's a credit to the engineers who put the SPAS together that it could take the kind of hits that it took."

On this second excursion away from the SPAS, Hauck went no further than 61 m. He held the Orbiter station keeping at that distance for a time while the crew did another evaluation of *Challenger's* rendezvous radar. At 16:30, he began moving the Orbiter back toward the SPAS, testing the spacecraft's ability to fly a very difficult and challenging out-of-plane approach.

Shortly after 17:20, Ride successfully captured the SPAS for the final time and, 20 minutes later, it was safely back in the payload bay. Recalling STS-5's "We Deliver" motto, Crippen told MCC-H that on "Flight 7, we pick up *and* deliver!"

The crew was very tired after a long day involving extreme concentration and as a result they turned in for the night less than one hour after berthing the SPAS back in the payload bay. It had been a very successful day.

Mission Day 6

What was scheduled to be the last full day in space began with a wake-up call from MCC-H at 04:16 on 23 June. It was to be a "wrap-up" day for most of the scientific experiments as well as a day of preparation for the reentry and landing scheduled for Day 7.

There was a considerable amount of uncertainty however, about just when and where the landing would take place. For this mission, *Challenger* was scheduled to make

A superb overall view of the Orbiter as seen from the SPAS during Prox Ops.

the first landing on the Kennedy Space Center's 5.2 km long Shuttle runway. This would mark the first time that any manned or unmanned spacecraft had ever returned to its launch site. Over the preceding few days however, the KSC weather had been poor, and the forecast for Day 7 was for more of the same. If conditions did not improve by the scheduled landing time, the crew would be forced to either stay up a day or two longer to wait for the Kennedy weather to clear, or divert to Edwards Air Force Base in California. Mission planners considered the KSC landing to be an important objective, and they were willing to keep the Orbiter in space a few days longer in order to get it in, even if the weather at Edwards was perfect on the planned landing day. MCC-H engineers estimated that an extension of two and even three days was possible.

Kennedy was the preferred choice for two reasons. First, because it would eventually be the nominal landing site for most Shuttle missions in the future, NASA wanted to get a Kennedy landing under its belt as soon as possible to demonstrate that it could be done. For various operational reasons, both Mission 8 and 9 would be required to land at Edwards, and with the recent cancellation of Mission 10, that meant that after STS-7, the next chance to try a KSC landing would not come until STS-11 in early 1984. Secondly, a Kennedy landing would cut about a week off the already tight turn-around schedule required to get *Challenger* ready for STS-8 by mid-August 1983. This was largely because no cross-country 747 ferry flight would be needed.

But the Kennedy forecast did not look favourable. The rain and thunderstorm activity that had been in the area were expected to be gone by landing day, but the heavy cloud cover would still linger.

"Crip," capcom asked, "anybody up there got any firm commitments for the weekend? It's really looking bad over the Cape." The thinking in Mission Control early on Day 6 was clearly along the lines of extending the flight. This set perfectly well with the astronauts, who were all enjoying themselves and were not really looking forward to coming down. Crippen said jokingly that the five of them were prepared to stay up "six, eight, ten days or longer... whatever it takes."

Unfortunately, all hope for an extended flight vanished less than two hours later when a problem was noted in one of *Challenger's* three Auxilliary Power Units (APUs). The hydrazine-powered APUs are turbine devices which provide hydraulic power to drive the Orbiter's aerodynamic control surfaces. As part of the normal pre-entry preparations done on every flight, Shuttle crews perform a thorough checkout of the Orbiter's Flight Control System (FCS) on the day before the scheduled landing. As part of this checkout, one of the APUs is normally started up to allow the pilots to perform a quick movement check on all the aerosurfaces.

At about 07:00, Crippen and Hauck began their pre-landing FCS checkout. Things were going well until they started APU-3. The APU ran normally for about 40 seconds, before suddenly going into an underspeed condition and automatically shutting itself down. No one was quite sure why. Hauck re-started the APU and it ran normally, which led engineers to think that the failure may have been of a transient nature, possibly caused by a bit of contamination in the fuel line which had since flushed its way out. But no one was sure.

In any event, APU-3 was suspect, and flight controllers decided that it would not be prudent to keep *Challenger* flying any longer than absolutely necessary. The Kennedy Space Center would still be the primary landing site, but if the weather there was bad, rather than waiting a day or two for it to clear, the Orbiter would come in to Edwards.

With the now-certain knowledge that they would be coming home the next day, the Mission 7 astronauts finished off the last of their scientific and technical investigations before packing things up for the landing.

Ride did some final processing work with the CFES, running three more samples through the unit before flushing its lines out and closing it down.

Thagard finished up the last of his motion sickness research using himself and his four still perfectly healthy crewmates as test subjects. He starred in a live TV show from the mid-deck in which he described his work and some of the equipment, using Fabian as his demonstration subject.

For his part, Fabian used the RMS to once again unberth the SPAS for some additional testing. This time, the arm itself rather than the pallet was the item being evaluated. Engineers wanted to see how the arm would behave with the 2200 kg SPAS attached to it. Fabian used the arm to manoeuvre the SPAS to various locations around the Orbiter. At each stopping point, he held the arm in position while Crippen and Hauck fired *Challenger's* RCS thrusters to induce some vibration to the arm. The object was to see how much the arm would move as a result of the acceleration from the thrusters, and how long it would

Commander Crippen shows concern as he flies the Orbiter from the aft flight deck during the first phase of Proximity Operations with the SPAS.

take for any arm motion to damp. Live TV pictures of the operation showed spectacular plumes each time the thrusters fired, but very littly dynamic activity on the arm. The RMS seemed to be a very stable structure. Fabian re-berthed the SPAS at 12:30, just minutes before the tired pallet satellite's batteries ran out.

After lunch, the astronauts spent the bulk of the afternoon packing to come home. Notebooks, checklists, cameras and other equipment all had to be put into specially-designated lockers on the mid-deck. The three mission specialist seats had to be brought out of storage and set up, and all of the checklists and cue cards Crippen and Hauck would need to fly the entry had to be unstowed and set up around the cockpit.

Challenger and her second crew were ready to come home. At 18:46, capcoms Guy Gardner and John Blaha sang a rather off-key duet bidding the crew goodnight, receiving moans of agony from space in response.

Mission Day 7

The Mission 7 crew was awakened for the final time at 03:40 on 24 June to begin preparing for their landing, scheduled to take place in a little over seven hours.

Actually *Challenger* had three possible landing opportunities on Day 7. The first of these was the nominal end-of-mission landing plan and was the one MCC–H and the crew were shooting for. It involved the Orbiter firing the OMS retro burn at 09:57 on Orbit 95, resulting in a landing at Kennedy Space Center at 10:54. If that opportunity had to be passed up, *Challenger* had another chance at Kennedy on the following orbit, firing the deorbit burn at 11:32 and landing at the Florida spaceport at 12:30. If that pass too had to be waived, then the crew would be committed to landing at Edwards Air Force Base. KSC would be beyond the Orbiter's crossrange capability by that time. The Edwards plans called for deorbit at 12:56 and landing a little over an hour later at 13:57.

As expected, MCC–H watched the weather very closely during the night. For a time, the questionable weather at Kennedy actually became fairly good. Stars could be seen in the sky overhead, and NASA officials began to think optimistically. By 06:00, conditions had again deteriorated. Astronaut John Young, flying over the spaceport in a T–38 jet trainer, reported thickening clouds overhead and patchy ground fog around the runway.

Using Young's information, Flight Director Gary Coen made the decision at 06:41 to wave off for one orbit, thus permitting *Challenger* to try for the second KSC opportunity. This decision was made in the hope that another 90 minutes of sunlight might help to burn off some of the clouds and fog. The nominal first opportunity at KSC had been scheduled for less than half an hour after local sunrise, too early for the Sun to be of much help.

At about 07:30, MCC–H gave the crew a GO to close the Payload Bay Doors and, once that was completed, the five astronauts began their landing preparations in earnest. The computers were re-configured with the entry software, the final Inertial Measurement Unit alignment was made and the star tracker and vent doors on the Orbiter were closed and sealed. Everything seemed to be cooperating except the usually beautiful Florida weather.

Young, once again flying in a T–38, reported at about 07:40 that the fog was so bad at the northern end of the

The Shuttle Mission 7 astronauts pose for a group photo during their seven-day flight. From left, they are, Dr. Norman E. Thagard (Mission Specialist-3), Robert L. Crippen (Commander), Frederick Hauck (Pilot), Dr. Sally Ride (Mission Specialist-2) and John M. Fabian (Mission Specialist-1). *All photographs NASA*

5 km long runway that he could not see the landing strip's threshold. He told MCC-H that the fog extended as far west as Orlando and as far north as he could see. "I just don't know what's going to happen," he said, "It's terribly hard to predict what this stuff will do when the Sun comes up."

By dawn, the veteran astronaut took the Gulfstream-2 Shuttle Training Aircraft (STA) up to begin practising simulated Orbiter approaches to the runway. By that time, conditions were so poor that he actually had to abort three of the simulated landings because the weather was below the Gulfstream's flight safety minumum. STS-2 astronaut Joe Engle, flying in a T-38 at the same time, found conditions around the whole KSC area to be just as bad. Both astronauts recommended to Flight Director Coen that the landing plans for Kenney be abandoned. Coen concurred, and at 10:35 the astronauts were told "we are NO-GO for KSC."

The astronauts were clearly disappointed. Crippen in particular had worked very hard to prepare for the KSC landing, but he took the decision in stride, replying, "We'd really like to have gone in there very much, but if the weather is bad, that's not the right thing to do, and we understand."

With the decision made, preparations at Edwards jumped into high gear. For this mission, the California site was considered a contingency landing area and, as a result, it did not have the full complement of personnel and convoy vehicles that it had normally had for past landings. All of that was now at Kennedy. Edwards had just enough equipment to safely power down the Orbiter and remove the crew. Additional safing would have to wait until more equipment and technicians could be flown in from Florida.

What Edwards did have was perfect weather. Astronaut Dick Truly, aloft in NASA's second Gulfstream STA, found the base's skies to be perfectly clear with very light winds blowing. Based on Truly's recommendations, lakebed runway 15 was designated the primary landing strip with runway 23 as alternate.

The crew successfully fired *Challenger's* two OMS engines at 12:56:00. The engines burned for 2 minutes and 48 seconds, slowing the Orbiter down by 94.55 m/s and starting it on its long powerless glide down to Earth.

The entry was to be a particularly difficult one. This was because the groundtrack was located such that *Challenger* had to eliminate 1367 km of crossrange distance northward in order to reach Edwards. This was only 22 km inside the maximum capability of the Orbiter for this mission. It was also the most crossrange flown in the Shuttle programme to date. Mission 4's 1076 km held the record up to this time.

As a result, modifications were made to the nominal STS-7 entry plan. Several Programmed Test Inputs (PTIs) were planned during the descent to allow engineers to obtain more data on how the spacecraft handled at various altitudes and velocities. These were all eliminated until after blackout when MCC-H would be able to assess *via* telemetry the Orbiter's energy state. With so much crossrange to fly, flight controllers did not want to risk losing even 1 km of capability by performing the PTIs. If the guidance was on target, then MCC-H would give Crippen a GO to perform the remaining manoeuvres.

As most people expected, *Challenger* did indeed come out of the entry blackout with perfect energy, groundtrack and guidance. Crippen reported that the descent had been "nice and smooth all the way down," and MCC-H gave him a GO to perform the remaining five PTIs planned. These were all done perfectly, providing engineers with still more data on the Shuttle's aerodyanmic handling capability.

The remainder of the descent was flown right by the book. *Challenger* returned to a relatively lonely Edwards Air Force Base, where only a few hundred technicians and spectators were on hand to greet it in contrast to the hundreds of thousands of onlookers assembled at Kennedy who were now forced to either watch the landing on television or listen to it over the PA system. *Challenger* did not even have the customary chase plane escort during its final approach. All the pilots that were trained to fly the difficult rendezvous with the descending Orbiter were at KSC too.

But none of that mattered to Crippen, who brought *Challenger* in to a landing with the same degree of perfection achieved on all six previous missions. The Orbiter's rear wheels touched the surface of Runway 15 at 13:57:10, kicking up billows of dust off the dry lakebed surface.

As *Challenger* rolled nearly 2 km before coming to a stop, capcom congratulated the five astronauts, telling them that he had "some good news and some bad news... the good news is the beer is very very cold this morning. The bad news is it's 3000 miles away (at Kennedy!)."

"That's what I was afraid of!" Crippen laughed as the Orbiter came to a stop. The largest crew ever to fly into space aboard a single spacraft was home after a flight lasting 6 days 2 hours 24 minutes and 10 seconds.

Aftermath

An inspection of *Challenger* immediately after landing revealed that it was in good shape. Lt. General James A. Abrahamson said that the "anomaly count" as of just after landing stood at 21. That is, up to that time, engineers had counted 21 problems of one kind or another that would have to be corrected before *Challenger* could again fly. This was less than any previous Shuttle mission, an indication of the programme's maturity.

Among the problems were: a malfunctioning toilet, a damaged windhsield, badly damaged brakes on the starboard main landing gear (pieces of broken brake rotors were retrieved from the runway), a malfunctioning hydraulic accumulator and, of course, the possibly defective Auxilliary Power Unit No. 3. None of these problems, however, were deemed serious enough to pose any potential threat to the launching of STS-8, which was set for the Shuttle programme's first night launch in mid-August 1983.

NOTES

1. Information on the design and characteristics of the Hughes HS-376 comsat may be found in the "Comsat News" section of *Spaceflight*, August-September 1981, p.205.
2. Additional background information on the SPAS-01 may be found in D.E. Koelle's article "Reusable Satellite Platforms" in *Spaceflight*, March 1982, pp.119-123.
3. The Camden GAS effort was particularly noteworthy because some of the students who worked on it were underpriveleged young people who previously had no interest in science whatsoever. Some were even considering dropping out of school. The excitement of being directly involved in the development of a Shuttle experiment has sparked many of these students on to earn scholarships to study space science and technology at universities.
4. Detailed information on the CFES may be found in Craig Covault's article "Payload Tied to Commercial Drug Goal" in *Aviation Week and Space Technology*, 31 May 1982, pp.51-57.
5. An excellent article giving background information on the MLR can be found in *Spaceflight*, November 1982, pp.396-397.
6. See Craig Covault's article "TDRSS Deployment Involves Complex Operations" in *AWST*, 17 January 1983,

FROM THE SECRETARY'S DESK

Thanks for the Memory

Battle-worn, but victorious, Shirley Jones and Susan Mandry settled down to enjoy their respective nervous breakdowns over Christmas. This highlight in their lives stemmed from the introduction of word-processors and the consequent agonies in coming to terms with the print-out equipment at Unwins (our printers).

For those not immediately conversant with the problem, the jist is that material put into the word-processors must be accompanied by coded instructions (there are thousands of these) to indicate the style and size of typefaces to be used, whether bold, italic, etc., subscript or superscript, paragraphs, lengths and thicknesses of lines, beginnings and endings, positions, headings, sub-headings, sub-sub-headings, captions of various widths and so on.

The WP has to be told not only *what* to do but *when* to do it and *when to stop* it, or when to revert to something else. The typed result at our end looks absolute gibberish. One false move and the result comes out as complete rubbish at our printers' end, too.

With time flying by and problems mounting, there was great anxiety in trying to get the first issues underway. Fortunately, an endless series of major headaches was eventually overcome, so congratulations all round.

We have been using the word-processors for other things, such as the list of duplicate Library Books for sale. The advantage here is that books can be easily deleted from the list so that this can be constantly updated. The same thing is happening with minutes of Council and committee meetings. Drafts can now be set up and corrected subsequently with the minimum of effort. Here the bank of information (the memory) is proving very beneficial.

Panic Buttons

Along with most offices nowadays, the Society has had to increase its security arrangements by the addition of an alarm system. Whether this will deter would-be intruders has yet to be seen, but it certainly deters the staff. There is a requirement for a mile-a-minute sprint from the front door every morning to turn it off before it alerts the entire neighbourhood. This imposes a severe strain on those of us who are not so fas as we used to be.

Our cleaner, Maureen, is having it particularly bad. Lacking the required sprinter's build, her main line of defence consists of mumbling prayers to the Saints above, though I can't see them getting to the alarm before she does.

Direct Debits

Arrangements for paying subscriptions by Direct Debit this year have gone very well. Last year it was chaos because, although the banks had been told to cancel bankers orders and accept direct debits instead, hundreds of them did both! We then had to cope with massive extra work by contacting each member and his bank and then drawing cheques to arrange for refunds. It took months to get straight again.

This year, the number of members paying by direct debit has reached our target of 1,000 and is continuing to rise.

There is one small point which ought to be made clear. Direct debits are meant to cover *regular* payments such as subscriptions to magazines. Extra non-recurring saleable items are best paid for separately. Processing is then much quicker.

We still receive communications from members who give no address, or signature, or ask us to not reply because they are moving, or — even more surprisingly — send money without any covering letter or indication of the remitter!

So, to members who expected to hear from us but who haven't, please write again. We will deal with your request the moment we know who you are!

Artistic Licence

One thing the Society sorely lacks is an artist-member of creative ability, willing to donate some of his time and talents to our work.

Apart from the Daedalus mission badge, mentioned last time, our files are thickly-strewn with unfilled requests for this sort of help from every committee. A few years ago there was need for a membership card. Because there were no submissions we were left to our own devices. Fortunately inspiration struck and the result turned out well.

The latest in this area is our new *de luxe* style membership certificates. Which are really very nice indeed. They are printed in two colours, the border being in gold to mark our 50th Anniversary. They bear the Society's new seal, which incorporates our logo.

Members can get one on remitting £5. Early delivery isn't promised as, for added attractiveness, each certificate will be inscribed by hand. They will be worth waiting for.

Membership Probes

The Council believe that great opportunitios exist for promoting space by expanding our activities and strength, enhancing our status and expanding our influence in the national and international scenes. Their first lines of attack lie in improving the appearance of *Spaceflight*, its coverage of world space news and as a major source of new ideas for space studies, supported by important meetings and an expansion in the staffing and other backup facilities needed to ensure success.

The Society fully intends to maintain its position in the very forefront of space developments. In 50 years we have created a reputation for soundly-based concepts. With exciting new ideas and projects coming into view we intend to exploit every opportunity as before.

A vital element in all this has to be the size of our financial base, hence our promotion to secure more Society publicity and increased membership.

Things are beginning to move. Join us to give a hefty shove.

Society Motto

The late Harry Ross was much concerned that the Society ought to have a motto, aptly describing its aims and aspirations. Sad to say, no-one came up with anything remotely appropriate to this worthy task.

A throwaway comment by Roy Gibson brought this one to mind the other day. His truism ran "For every complex problem there is always a quick, easy answer — which is false!"

SALYUT MISSION REPORT

By Neville Kidger

Readers will be pleased to know that the popular series of reports on the progress of Soviet manned space flights are making their re-appearance in *Spaceflight*. The report below continues from that included in the October 1983 issue of *JBIS*.

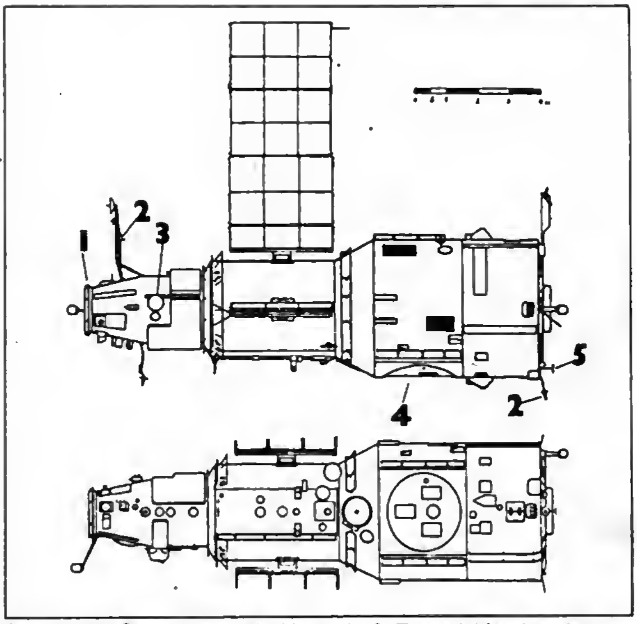
The Soyuz T-8 Failure

As recounted in the last part of the Salyut 7 Mission Report, the Soyuz T–8 crew failed to dock with the space station. Few details about the reasons for the failure were released at the time but, in a refreshingly frank article in the *Red Star* newspaper (the Soviet armed forces daily newspaper) in August, Soyuz T–8 commander Vladimir Titov elaborated on the failure.

As suggested in the Mission Report, the Soyuz T–8 problems began early in the flight. According to Titov, on the second orbit (contrary to official Soviet statements) Soyuz T–8's rendezvous antenna, which provides range data to the Argon BTsVK computer, failed to fully deploy from its stowed position. (At least one western source claims that the antenna was broken off during launch when the launch shroud of the carrier rocket was jettisoned).

"Tests" of the attitude control motors, admitted by the Soviets, were in fact attempts by the crew to "wiggle" Soyuz and deploy the recalcitrant boom. These attempts failed and the cosmonauts were told that the attempt to dock with Salyut would be cancelled. However, Titov asked for, and was granted, permission to attempt a docking without the information which the rendezvous antenna would have provided on the distance and the closing speed between the two craft. Titov intended to fly the first ever totally manual approach and docking with a space station. He had to estimate the area that Salyut covered in the Soyuz periscope display using recticule markings to help. From this information the Flight Control Centre (FCC) estimated the distance and advised Titov what maneouvres to make. Soviet pilots are able to dock manually from about 1 km provided that range and closing speeds are known, a feat accomplished by both the Soyuz T–2 and T–6 commanders.

On orbit 19 Titov had Salyut in sight and was



Salyut 7. 1. Strengthened docking unit. 2. Two additional rendezvous antennae. 3. Porthole with new protective cover. 4. X-ray instrumentation. *Dietrich Haeseler*

approaching rapidly after performing a 50 second burn on the ODU (the Soyuz propulsion system). However, before further instructions could be passed up from FCC Salyut and Soyuz moved out of the range and into orbital night. With T–8 on final approach, Titov used an external searchlight to illuminate Salyut's rear docking unit (Cosmos 1443 was docked on the front unit). Unfortunately, Titov was so uncertain about the distance that he feared a collision and aborted the approach by a short ODU burn which pulled Soyuz away. By the time Soyuz T–8 reentered radio contact the two vehicles were separated by over 4 km. Titov reported that he had approached to within only 160 m before deciding to abort.

The limited quantity of fuel available to Soyuz decided the FCC controllers to abandon any further attempts and recall the three man-crew to Earth.

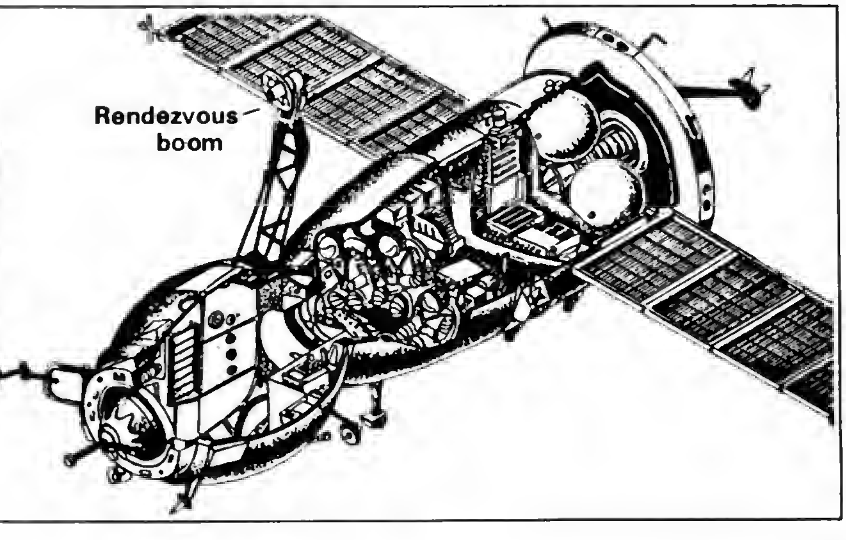
The Salyut 7/Cosmos 1443 combination did not have to wait too long for its next visitors. In mid-June 1983 the Cosmos was used to alter the orbit to one suitable for the launch of a new two man-crew.

Again the "Protons"

As noted in the last part of the Mission Report, cosmonauts Lyakhov and Aleksandrov were training for Salyut 7 missions, in particular the third long-term expedition (see "The Soviet Cosmonaut Team 1971-1983" in

Soyuz T Principal Characteristics

Crew	**2-3 persons**
Weight	**6,850 Kg**
Weight of descent module	**3,000 Kg**
Length of body	**6.98 m**
Maximum diameter	**2.72 m**
Span of extended solar battery panels	**10.6 m**
Type of booster rocket	**Soyuz**



The Soyuz T-8 crew (from left): Serebrov, Titov (commander) and Strekalov. *Novosti*

JBIS October 1983). For Vladimir Lyakhov it would be a second trip into space. On the first, he and Valeri Ryumin established a space flight duration record of 175 days. Later, Lyakhov was reserve commander for the Soyuz 39 Soviet/Mongolian flight to Salyut 6.

Aleksandr Aleksandrov was a newcomer to space. He worked for many years in the Korolev Design Bureau as an engineer and in 1965 he applied to join the cosmonaut group. He was told to wait. He was accepted as a cosmonaut in 1978 along with fellow engineers Serebrov, Savinykh and Solovyov. Aleksandrov met his wife while working at the bureau; she was a FCC staff member and would be in regular contact with him in orbit. Aleksandrov was 40 at the time of the flight. The two-man crew had the call sign of Protony — the Protons.

Soyuz T-9 in Orbit

Soyuz T-9 was launched from the Baikonur Cosmodrome at 0912 (all times GMT) on 27 June 1983. Within nine minutes the spacecraft was in orbit. After a trouble-free approach the Soyuz ferry docked with Salyut's rear port just a few seconds after 1046 on 28 June. TV views of the docking were overlain with displays from FCC and were shown later on Soviet TV. The total weight of the three-craft complex was about 47 tonnes.

After two orbits docked to the station, the Protons entered Salyut and began activating the life support systems and unstowing equipment. Lyakhov, who had experienced problems in adapting to weightlessness on his first mission, noted with satisfaction that he was adapting easily this time. Aleksandrov initially noted a rush of blood to his head and a feeling of thirst but was soon adapting normally to the strange environment.

Speaking at FCC, Salyut 7 Flight Director Valeri Ryumin told reporters that the Protons' flight would be shorter than the 211 day flight completed in 1982 but noted that the cosmonauts would be very busy with an extensive scientific programme and unloading and testing the Cosmos module.

On 29 June Tass announced the orbital parameters as: 328 x 343 km, 91.1 minutes and inclination 51.6°. The internal temperature was 18°C (64°F) and the pressure 750 mm of mercury.

Into Cosmos 1443

In the midst of their reactivation work, at 0849:15 on 30 June, the Protons opened the internal hatches of Cosmos 1443 and moved inside. Lyakhov said that the interior had "the usual technical smell, nothing else" and likened the interior to a well-stocked warehouse with equipment on racks mounted on the walls. In total, Cosmos contained over 600 items, including scientific equipment and foodstuffs with a limited "shelf-life."

The Soviets noted that, as with Romanenko and Grechko using Progress 1, the Protons would have a "learning curve" as they unloaded Cosmos. Their experience would benefit later crews. Areas emptied in the Cosmos were quickly filled by used filters, regenerators and other junk. By the end of their first week in orbit the Protons had cleared all cargo from the Cosmos Descent Module and, by 23 July, had unloaded some 50% of the heaviest and bulkiest items.

Establishing a Routine

By the end of their first month in space the Protons were exhibiting a high working capacity and an "uncommonly good appetite." They even gained weight (1.5 to 2 kg each) despite their heavy schedule and 12 hour working days. On the 175 day flight Lyakhov also gained weight.

Unlike earlier crews, the Protons were expected to work for half-a-day on Saturdays rather than have the whole day off. The routine was devised to prevent the crew overworking on their scheduled work days. The Protons were often caught out by doctors at FCC working in off-duty hours during the early part of the flight and there was genuine concern they would become fatigued by overwork. A rule was established that if they fell a day behind schedule then they were to be given an extra rest day. Generally, they were able to catch up with their schedule on the same day if they fell behind. They were also expected to continue with their intensive daily exercise routine.

Micrometeorite Scare

On 25 July, the Protons reported to FCC that they had heard a sharp "crack" which surprised them. They

discovered the cause was a micrometeorite striking one of Salyut's windows. The impact had caused a 4 mm diameter crater in the window and the micrometeorite itself appeared to have become stuck in the glass. Although there was no danger from the impact (Salyut's windows are double panelled, each 14 mm thick) the cosmonauts found the incident amusing, FCC was quick to point out that there were emergency procedures in the event of a puncture.

The minimum time needed to close down Salyut's major systems and reactivate Soyuz's was given as 15 minutes. FCC expected that an actual puncture would require 90 minutes for the crew to safely isolate themselves in Soyuz. In theory the crew could spend several days in Soyuz in safety but, in reality, the crew would land at one of the many reserve sites in the USSR, USA, France and other countries. If this occurred, FCC directors said, international agreements would ensure the safe return of the crew and capsule to the USSR.

In an ironic twist, FCC revealed that the impact had occurred during a simulated emergency evacuation drill!

A Busy Work Schedule

The Protons worked hard during July to conduct over 80 experiments, including a series of geophysical investigations on behalf of some 600 Soviet enterprises. Studies of Brazil were requested by Unesco and the crew observed the countries of the Intercosmos organisation. By the end of this period, after just one month in orbit, the Protons had used up half as much film as the Elbrusy had in the whole of their 211-day flight and as much as some of the earlier long term flights had during the whole of their flights.

For Earth observations the Protons used the Salyut's stationary photographic apparatus (MKF-6M Multi-spectral camera and KATA-140 Topographic camera) and spectrometers made in Bulgaria (Spektr-15M) and the GDR (MSK-M). In addition to their regular photography

Soyuz T-9 approaches to dock with Salyut 7's rear unit on 28 June 1983. *Novosti*

Comparison betweeen Salyut 7 and Cosmos 1443.

	COSMOS 1443	SALYUT
Length of module (m):	13	13.5
Maximum diameter (m):	4.15	4.15
Mass in orbit (t):	20	18.9
Number of compartments:	2 (Orbital and Descent)	3
Volume of orbital module (m^3):	50	90 (total)
Number of solar panels:	2	3
Wingspan across solar panels (m):	16	17
Area of solar panels (m^2):	40	60
Power from solar panels (kW):	3	4
Cargo return capacity of Descent Module (kg):	500	N/A

of test areas of the USSR, imaged by all of the Salyut crews, the Protons concentrated observations on agricultural areas in Central Asia (to determine the amount of weed infestation) as well as areas around the Caspian Sea, Volga River, Ural Mountains, Sea of Azov, the Crimea, the Caucusus and BMA railway route. During a 14-day period some 3,000 photographs were obtained.

Simultaneous observations were made over several sites by the Meteor-Priroda satellite launched in June 1980 and equipped with the "Fragment" multi-spectral imaging system. A harmless dye was released into the Black Sea, spreading out to a diameter of 500 m — the Protons located the dye, described its colour and photographed it. Observing the same event were an AN-30 aircraft 8 km high and the Meteor satellite. The test was preparation for a 20-day intensive study of the Black Sea area for the Intercosmos organisation which began in late August.

Many early attempts to photograph areas of the Atlantic Ocean were frustrated by clouds. During his 175-day flight Lyakhov had been awarded the title "Outstanding Worker in the Fishing Industry" by the Soviet Marine Agency because of his work in locating plankton fields in the oceans where large shoals of fish had congregated. More recently, Valentin Lebedev was awarded a "Distinguished Prospector" badge by the USSR's Minister of Geology in recognition of his work in Earth observations during the 211-day flight. He is the only cosmonaut to be awarded the high Soviet honour.

The Protons took many still and movie films of lightning bolts and auroral phenomena on the night side of the Earth.

Speaking about their work, the cosmonauts agreed that specialisation on one aspect of scientific research, e.g. Earth observations or astronomical research, would lead to a greater scientific return than possible at present. However, specialised research is difficult in the current Salyut stations owing to the crew size and the many conflicting requests from organisations using Salyut-derived data. Such specialisation will need to wait until larger complexes are operating permanently.

Using the Astra-1 mass spectrometer, the Protons discovered that Salyut was followed in space by a "comet's tail" of waste matter such as exhaust from the attitude control motors and air and garbage from the ShK airlock. The tail was of concern to astronomers because of the problems it may represent in the future when long exposure astrophotography is being conducted. During his photography sessions, Lyakhov often shut himself in the Forward Transfer Compartment with all lights extingushed to cut down the amount of scattered light.

Manoeuvring the Complex

An important part of the Protons' programme while Cosmos 1443 was docked to Salyut 7 involved testing the attitude control system. This was the first time that two stations of such large mass had been docked in space and, with the Soviet confirmation that all future space station complexes will be modular, an understanding of the dynamics was vital for future plans.

The Soviets said that theoretical studies showed substantial savings in fuel would result from a new control system developed for the complex. The prediction was that only one-fifth or even one-seventh of the normal fuel load and oxidiser would be expended. However, Lyakhov's first attempts at manual control used much more fuel than predicted. He later admitted that his lack of experience had much to do with the extra usage.

New Experimental Tasks

As the Protons completed their initial Earth observations tasks, in the first week of August, their focus in experimental work moved to biological and technological tasks. In particular the crew:

- Monitored and fed plants placed in Salyut's biological installations. These included a dwarf wheat plant which thrives in arid areas of Earth.

- Continued materials smelting experiments in the Kristall and Magma-F furnaces. Cadmium theioselinide was processed in the Magma-F; it is a material with important uses in laser and communications technology.

- Used the electrophoresis installation to process pure biological materials of uniform purity under the Gel experiment codename. Previous Gel experiments showed that 50–100% improvements in uniformity were possible under the microgravity conditions of orbital flight.

- Conducted tests of the Electrotopograph instrument to record on film the variations on the surface of various materials exposed to space via the ShK airlock for differing periods. The instrument was claimed to be capable of registering variations of less than 10^{-11} m.

- Used an improved version of the Yelena gamma ray detector to continue studies of gamma quanta begun by Salyut 6 crews. Previously, the detector discovered high-energy electrons with energies of tens to hundreds of MeV close to Earth. The discoveries were confirmed by instruments of the Bulgaria 1300 satellite. The Proton's studies were aimed at the flux of particles at various geomagnetic latitudes, mapping their extent and characteristics.

While working in the Cosmos module, Lyakhov found room to install a metalwork vice. The crew also moved the Chibis and EVA suits into the module to create more room in Salyut. Lyakhov suggested that future versions of the Cosmos module should have a permanent shower to save the time and space needed to assemble and dismantle the shower in Salyut.

Restructuring the Complex

In mid-August the Salyut complex was changed to its more normal appearance. In preparation for the dynamic activities Lyakhov and Aleksandrov began, early in the month, to load various items into the Cosmos Descent Module for return to Earth.

In practices at the Yuri Gagarin Training Centre, Zvyodzny Gorodok, the crew had carried a great deal of equipment around from the Salyut to the Cosmos mock-up. Lyakhov claimed that his strength had improved during these simulations to the extent that he was able to unfasten bolts with his bare hands in space. During their space activities, the crew complained of tiredness and fatigue in their arms from all of the maneouvring of large equipment, despite the fact that the items were weightless.

The Protons loaded some 350 kg of materials into the Cosmos Descent Module. The cargo for return to Earth included films and logs, the results of 115 experiments, and items such as regenerators which had failed early and a defunct unit from the Delta navigation computer for inspection.

At 1404 on 14 August Cosmos 1443 undocked from Salyut's front unit and maneouvred into an independent orbit. The Descent Module landed at 1102 on 23 August some 100 km southeast of Arkalykh. The main vehicle was de-orbited at 0034 on 19 September over the Pacific where it broke up in the atmosphere. There were reports from the USA that Cosmos had suffered a serious malfunction during its Salyut phase, but the Soviets made no comment.

At 1425 on 16 August the Protons, after having floated into the Soyuz, undocked Soyuz T-9 and withdrew to a distance of 250 m from Salyut 7. Salyut was then commanded to turn 180° so that its front docking unit faced Soyuz. T-9 then redocked. The whole operation took only 20 minutes and was completed over Kazakhstan.

The next day at 1208, Progress 17 lifted off from Baikonur loaded with fuel and consumables for the crew. Docking with Salyut's rear unit was accomplished at 1347 on 19 August. The Protons soon had the hatch of the cargo ship open and were set to unload the new equipment.

During the unloading the Protons conducted further observations of the station environment with the Astra-1 mass spectrometer, performed more medical tests on themselves and completed another extensive series of Earth observations in early September. FCC noted that the cosmonauts were demonstrating a high work capacity and were maintaining good personal relations. Refuelling of the station was underway by 7 September.

To be continued

Soyuz-Salyut flights 1982-1983

Soyuz	Crew	Callsign	Backups	Duration
T-5 (T-7)	A. Berezovoi V. Lebedev	Elbrusy	V. Titov G. Strekalov	13 May-10 Dec 1982
T-6	V. Dzhanibekov J. Loup-Cretien A. Ivanchenkov	Pamir	L. Kizim P. Baudry V. Solovyov	24 Jun-2 Jul 1982
T-7 (T-5)	L. Popov A. Serebrov S. Savitskaya	Dnieper	? ? ?	19-27 Aug 1982
T-8	V. Titov G. Strekalov A. Serebrov	Okeany	V. Lyakhov A. Aleksandrov ?	20-22 Apr 1983
T-9	V. Lyakhov A. Aleksandrov	Proton	V. Titov (?) G. Strekalov (?)	27 Jun-23 Nov 1983
(Abort)	V. Titov G. Strekalov	Okeany	? ?	27 Sep 1983

Copies of the October 1983 "Soviet Astronautics" JBIS are still available at £2 ($4) each, post free.

The Latest Developments from Cape Canaveral in Florida

By Gordon L. Harris

NO MARRIED CREWS YET!

Although only four missions got off the ground during the Shuttle's third year, NASA hopes to launch 10 during 1984. They will carry 50 astronauts, mission and payload specialists. Six women are included. Three husband-wife astronaut pairs will fly but none will travel together. Sally Ride's husband, Steven Hawley, will accompany Judith Resnik on Mission 41D on 4 June. Dr. Rhea Seddon will fly on Mission 41F on 9 August while husband Robert Gibson flew in the 41B crew in February. Dr. Anna Fisher will be in 41H during September and husband Dr. William Fisher will fly 51C in December.

SHUTTLE BOOSTER BIDS

NASA has requested bids for a Shuttle booster assembly and refurbishment contract presently held by United Space Boosters, Inc. The contract will cover refurbishment, assembly and checkout of 84 flight sets of Solid Rocket Boosters. The winner must also construct a facility at KSC to house operations. The work is now performed in the Vehicle Assembly Building and other facilities. A new plant will increase deliveries to a maximum of 24 flight sets per year.

KENNEDY REMEMBERED

KSC veterans remembered 16 November 1963, the day when President Kennedy visited the launch area, then under construction, to see the first Saturn 1 vehicle poised on Complex 34. Six days later he was assassinated in Dallas.

It was Kennedy's third visit. Astronauts Virgil Grissom and Gordon Cooper, with Deputy Administrator George Low, briefed him on the planned Gemini programme. George Mueller, heading Apollo, talked of the progress made in developing Saturn boosters while Dr. Wernher von Braun escorted him to the pad where he saw Saturn. Dr. Kurt Debus, then director of the Launch Operations Center, accompanied Kennedy on a helicopter trip from which the President saw the beginnings of massive facilities for Apollo lunar launches. He was visibly impressed.

SPACELAB ATTENDANCE

Press attendance for the launch of STS-9 fell to the lowest total of the Shuttle programme: 867 photographers, reporters, TV and radio personnel, including 114 from foreign countries. Turnout of public relations employees of NASA contractors continued to be high with 130 operating a "Joint Industry News Center" in two caravans located on the press site.

For whatever reasons, the US media paid scant attention to the flight plan, which included an orbit inclined at 57 degrees to the equator. Within a short time after liftoff, STS-9 travelled eastward off Halifax, Nova Scotia, passed over the Firth of Forth, thence across Central Europe and the Soviet Union (near Sevastopol).

The 28 November launch was the ninth flight, *Columbia's* sixth and the first for Spacelab. The ESA-owned research facility was originally scheduled for 1980 but delays in Shuttle development forced a three-year wait.

NEW ASSOCIATE ADMINISTRATOR

Robert O. Aller has been named as Associate NASA Administrator for space tracking and data systems. He joined the agency in 1964. Since 1979, he has directed the Tracking and Data Relay Satellite System which, when fully operational, will replace many Earth stations of NASA's world-wide network.

SPACE STATION OR MILITARY?

The US aerospace industry cannot militarise space and build a manned civilian space station concurrently, Director John Gibbons of the Office of Technology Assessment has told a House of Representatives committee. "Recent and projected increases in military space expenditures will more than absorb the unused capacity of the aerospace industry," Gibbons declared. He urged Congress to phase in funding for a space station gradually or stretch out military projects.

THE COST OF SPACE

US manned space flight costs were published in a booklet prepared by the Kennedy Space Center for media usage during the Spacelab mission (cost in $million):

Mercury	392.6
Gemini	1,283.4
Apollo	**25,000
Skylab	2,600
Apllo-Soyuz	*250
Space Shuttle	
Design, dev. & test	***9,912
Production	***5,603

*US portion.

**Apollo mission cost ranged from $145 million for Apollo 7 to $450 million for Apollo 17.

***Estimated cost in 1982 dollars. Includes four Orbiters, long lead time items for a fifth, KSC and Orbiter ground support equipment, initial operating spares and equipment, systems integration and support activities. Does not include operational status costs.

The rounded-off totals include rockets, their engines, spacecraft, tracking and data acquisition, operations, operations support and facilities.

REPORT FROM BUDAPEST

In the February issue we carried the first part of a report on last year's IAF Congress in Budapest. Here we begin a review of the individual sessions.

CETI

For the 12th time the International Academy of Astronautics provided a lively forum for discussing many diverse aspects related to communication with Extraterrestrial Intelligence during its two Review Meetings on CETI held in conjunction with the IAF Congress. On the first afternoon, Soviet Academecian V.S. Troitskii countered the widespread belief that other civilisations will be far in advance of our own technology by suggesting that life may have formed everywhere in the Universe at the same cosmic epoch and that the rates of its subsequent biological and cultural evolution may be regulated by some unknown global laws independent of the individual site conditions. Don't expect any Cosmic Miracles — they're just like us!

Dr. M. Pagiannis of Boston University concluded that finite limits to available energy will inevitably lead to the survival of only those technological civilisations that curb their avarice and aggression.

It is not now possible to assess the public's appetite for personal commitment to what may well prove to be many lifetimes' worth or exploration. Dr. William Hilton suggested that old fashioned reaction feed-back receivers may offer SETI sufficient gain in sensitivity such as to warrant their use in spite of their extremely non-linear amplification. Unfortunately, time did not permit any discussion of the radical suggestion by Dr. Jack Corliss that the first primitive forms of life on Earth "made their living" on the basis of sulphur-based chemosynthesis in 600°C waters surrounding the deep ocean vents rather than by carbon-based photosynthesis.

The second session was initiated by Dr. M. Klein with a lucid presentation of NASA's current R&D activities aimed at learning how to make a really significant systematic microwave search for ET signals in the near future. Dr. Ben Zuckerman agreed that our current technological capabilities and methods of antenna construction supported the rationale for a search at microwave frequencies. However, if "their" space engineers build high gain transmitters according to different scaling laws, infrared may well be the preferred place to look. Dr. Marx from Hungary wondered whether the constant temperature of the terrestrial atmosphere in the face of the evolving solar constant might be an artifact of another technological civilisation acting long ago. Dr. Subotowicz from Poland expanded last year's interstellar space flight calculations to consider, in detail, trips to the nearby stars. Dr's Tarter and Almar independently considered what effects the existence of extraterrestrial intelligence and the search therefore might have on the number of newly detected cosmic phenomena. Both chose to use a new text "Cosmic Discoveries" by Martin Harwit to provide a quantitative basis for discussion.

As in the past, these sessions drew large audiences possessed of strong opinions. Nobody was bored!

JILL TARTER

SPACE STATIONS AND PLATFORMS

An overview paper summarised the status of US, Canadian, European and Japanese studies on space station operations in the 1990's. An operating altitude of about 450 km and an orbital inclination of 28.5° with an initial crew complement of 4 to 8 people was indicated for the initial station. The several papers covered the gamut of space station operations quite well — with orbital transfer vehicle servicing and launch, tether applications, station-tended free flying platforms, and satellite servicing all treated. On-orbit servicing and launch of space-based vehicles was shown to be a major economic benefit of space station operations.

One paper treated the use of a near-equatorial platform, in conjunction with an electronuclear tug to enhance substantially the capabilities of expendable launch vehicles for placing spacecraft in geostationary orbit. Such a platform could be used in conjunction with manned or unmanned orbital operations.

A concluding paper on the ten years of international cooperation experienced to date with Spacelab provided an excellent back-drop for upcoming discussions during potential participants in an international space station programme.

The lack of USSR participation in this international oriented session drew pointed comment.

J.H. DISHER

SPACE MOTIVATED EDUCATION

This session was held on 11 October 1983, organised by the Supervision of Youth Research Experiments (SYRE) Subcommittee of the IAF Education Committe. It began with a paper entitled "Space: a Unique Educational Motivator," presented by Cathy W. Swan. It was an enthusiastic presentation which stressed the opportunity presented in sharing knowledge of what goes on beyond the atmosphere. The effects of these new concepts, shared by super-powers and the Third World alike, are sure to generate programmes which will bring an enthusiastic response from everyone.

Marcel Grün outlined student activity which could be of interest to many. There was a need to include studies of astronautics in the curricula of education in schools. Text books on the subject have been prepared and are used in physics courses. Because of rapid changes in the subject teachers are provided with updated teaching material.

A network of Observatories and Planetaria, originally set up for amateur astronomers, now provide information on astronautics in lectures, courses in space sciences for students and student groups whose members have an interest in hands-on projects of their own.

Betty B. Burkhalter gave an up-beat presentation about an educational programme for high school and middle school in Aerospace Science and its related technical aspects.

She pointed out the uncertainties that exist in present educational processes, and the appeal to students of things related to space. She outlined two programmes related to hands-on experience and the partnership concept with education, government and industry.

Guy Pignolet gave a sparkling demonstration of an operating model of a satellite with ground stations, simulating the radio up and down links with light beams. He suggests it is a feasible project for schools and youth clubs.

George James presented a paper reviewing "Forty Years of Supervised Student Rocketry," undertaken by the Rocket Research Institute. He credited the successful activity of this group in the design, construction and evaluation of student-fabricated rocket motors, payloads and flight vehicles to three factors:

1. Competent guidance.
2. Professionally designed equipment.
3. Availability of proper safety facilities.

B. Zečevic presented a paper which outlined in detail the performance of some micrograin rocket propellants. Hervé Moulin described the activities at the First European Launching Campaign, at Valdahon in October 1982.

Wadyslaw Geisler presented a paper which made reference to the need for people of all nations to support activities in space.

He pointed out that interest in space will broaden the perspective of all students, and contribute to the development of a world perspective.

E.A. QUARTERMAN

SATELLITE DIGEST-171

Robert D. Christy

Continued from the February issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

GALAXY 2 1983-98A, 14365

Launched: 2216*, 22 Sep 1983 from Cape Canaveral AFB by Delta 3920 plus Payload Assist Module.
Spacecraft data: 2.16 m diameter cylinder, initially 2.82 m long but extending to 6.7 m when telescoped solar array fully deployed. Mass 698 kg (1218 kg fuelled). The satellite is based on the standard Hughes HS-376 vehicle.
Mission: Commercial communications satellite offering 12 channels for sale or lease. The satellite was built and is managed by different divisions of Hughes.
Orbit: Geostationary above 74°W.

COSMOS 1500 1983-99A, 14372

Launched: 0800, 28 Sep 1983 from Plesetsk by F vehicle.
Spacecraft data: Not available.
Mission: Probably electronic reconnaissance.
Orbit: 633x665 km, 97.78 min, 82.54 deg.

EKRAN 11 1983-100A, 14377

Launched: 1737, 29 Sep 1983 from Tyuratam by D-1-E plus apogee motor.
Spacecraft data: Cylinder with a pair of boom-mounted solar panels and a flat aerial array at one end. Length 5 m, diameter 2 m and mass in geosynchronous orbit 2000 kg.
Mission: To transmit programmes of Central Television to collective receiving stations in remote areas.
Orbit: Geosynchronous above 99°E.

COSMOS 1501 1983-101A, 14380

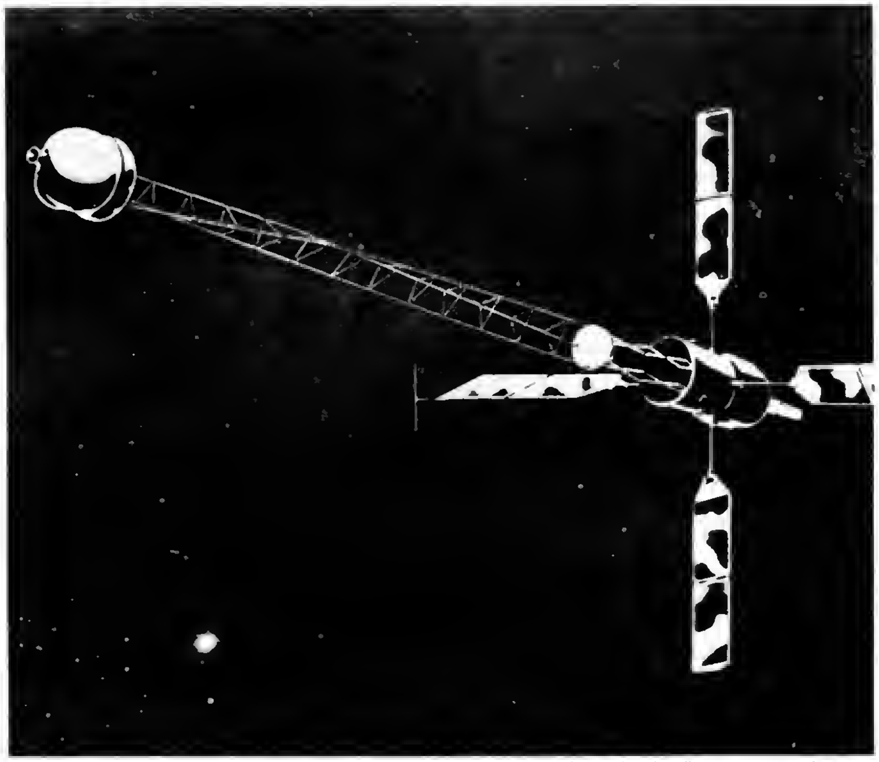
Launched: 1102, 30 Sep 1983 from Plesetsk by C-1.
Spacecraft data: Possibly cylindrical, about 2 m length and diameter, and mass around 700 kg.
Mission: Not available
Orbit: 466x512 km, 94.46 min, 82.94 deg.

COSMOS 1502 1983-102A, 14395

Launched: 1202, 5 Oct 1983 from Plesetsk by C-1.
Spacecraft data: Not available but may be similar to Cosmos 1501.
Mission: Not known.
Orbit: 368x411 km, 92.36 min, 65.85 deg.

COSMOS 1503 1983-103A, 14401

Launched: 0023, 12 Oct 1983 from Plesetsk by C-1.
Spacecraft data: May be similar to Cosmos 1501.
Missions: Military communications using a store/dump technicque.
Orbit: 788x808 km, 74.05 deg, 100.89 min.



An artist's impression of a US Navy Nova navigation satellite in orbit; the first was launched on 14 May 1981 to begin the replacement of the Transit series. *RCA*

COSMOS 1504 1983-104A, 14403

Launched: 1000, 14 Oct 1983 from Tyuratam by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6 m, diameter 2.4 m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered or re-entered after 23 days.
Orbit: 171x306 km, 89.29 min, 64.86 deg, manoeuvrable.

INTELSAT 5 (F-7) 1983-105A, 14421

Launched: 0045*, 19 Oct 1983 from Kourou by Ariane (mission L-7).
Spacecraft data: Box-shaped spacecraft body, 1.66x2.01x1.77 m with attached aerial mast of 4 m. The span across the solar panels is 15.9 m and the mass in geostationary orbit is 1012 kg.
Mission: Commercial communications, Intelsat 5 (F-7) is the first of the Intelsat series to carry a maritime communications package.
Orbit: Geostationary.

PROGRESS 18 1983-106A, 14422

Launched: 0959*, 20 Oct 1983 from Tyuratam by A-2.
Spacecraft data: Near-spherical orbital compartment, conical, non-recoverable fuel module and cylindrical instrument unit. Length approx 7.5 m, max diameter 2.2 m and mass around 7000 kg.
Mission: Delivery of consumables to the crew aboard Salyut 7. Progress 18 docked with the rear unit of Salyut 7 at 1134, 22 Oct 1983. It separated at 0308, 13 Nov 1983 and burned up following a re-entry manoeuvre at 0418, 16 Nov 1983.
Orbit: Initially 193x242 km, 88.79 min, 51.62 deg and manoeuvred to 240x305 km, 89.90 min, 51.61 deg as a transfer orbit. After docking with Salyut, the orbit of the complex was 318x357 km, 91.23 min, 51.59 deg.

COSMOS 1505 1983-107A, 14425

Launched: 1211, 21 Oct 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1504.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 356x414 km, 92.30 min, 72.88 deg.

COSMOS 1506 1983-108A, 14450

Launched: 1720, 26 Oct 1983 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in a drum-shaped solar array with length and diameter both about 2 m. The mass is around 700 kg.
Mission: Navigation satellite.
Orbit: 950x1014 km, 104.74 min, 82.92 deg.

The Solar System
M. Smoluchowski, W.H. Freeman & Co. Ltd., 174pp, 1983, £10.95.

It is interesting to reflect that we all belong to the first human generations able to see and know the Earth as an astronomical body, with space probes and manned expeditions to the Moon providing a unique new perspective on our Solar System, adding to the fascination of the Universe and the origin of life itself.

We belong to generations now able to see the planets, for the first time, not merely as bright objects in the night sky but in close encounter and with big surprises provided by many of the moons examined so far. At the present count there are now nearly 50 such moons, coming in different shapes and sizes and varying enormously in composition. Some appear to be nothing but ice, others almost entirely rock, and with Io, at least, blazing away in the night sky against every expectation.

In this book the author assembles many of the latest images from satellites and ground-based telescopes to present a picture of our Earth in its cosmic environment. Most are factual descriptions of what is presently known but with added text on topics like the birth of the Sun, the formation and eventual fate of the Solar System, and of the life it holds.

The text is extremely clear and very easy to read. The photographs and drawings (many in colour) which appear on virtually every page, also add greatly to its interest.

The New Solar System
J. Kelly Beatty, *et al*, CUP, 240pp, 1983, £6.95

When the *The New Solar System* was published in 1981, Voyager 2 was roughly three months away from its encounter with Saturn and closing fast. Before long, scientists who had barely a chance to digest the tremendous harvest of the first Saturn flyby were faced with a stream of new data on the ringed planet and its family of satellites. As the year closed, two Soviet spacecraft sped towards a landing on cloud-hidden Venus. Historic colour pictures and crucial chemical analyses of its mysterious surface were in store. On Earth, astronomers continued to coax secrets from the dim light of the Solar System's most elusive objects — comets, asteroids, and faint satellites — all the while revising and refining their interpretations of recent spacecraft findings.

The Solar System of today is in many ways the same as that of spring 1981. But there are enough differences to warrant a second look, and thus a second edition of this volume. An assortment of planetary maps has been added. The result will serve as a benchmark until the current hiatus in deep-space exploration has passed.

This is the paperback version of the second edition published in 1982.

The New Astronomy
N. Henbest & M. Marten, Cambridge University Pres, 240pp, 1983, £12.50.

This book undertakes the unique task of comparing optical observations of many of the most interesting and well-known astronomical objects with their counterparts in infrared, ultraviolet, radio and X-ray appearances, many of which are so strikingly different that it is hard to realise that the same object is being portrayed. The result is a galaxy of vivid new imagery created at wavelengths other than that of visible light.

These radio, infrared and similar observations reveal spectacular new detail and bring to view invisible aspects of astrophysical events, such the birth of stars, the aftermath of a star's death, or even eruptions in the cores of distant quasars.

Over 30 celestial objects have been chosen for examination, ranging from the planet Venus to distant quasars and supported by about 275 colour pictures, most produced only over the past few years and based on the most recent image-processing techniques.

The six chapters each deal with some specific aspect, i.e. the Solar System, starbirth, stardeath, the Milky Way system, galaxies and quasars. Each of the objects selected is introduced with an optical photograph to provide a key to its subsequent appearance in radio, infrared and other wavelengths. There is accompanying text describing how these new-type observations have expanded our knowledge of objects previously known only in the optical band and how these have often led to valuable new discoveries.

For the non-technically inclined, further text has been added to explain not only how astronomers actually make these observations at different wavelengths but also the physical processes which have occurred to produce the observed radiation in the first place.

Galaxies
T. Ferris, Stewart, Tabori & Cheng, 192pp, 1983, £7.95.

Although radiating the light from billions of suns, most galaxies are so distant that they appear very faint, with just three visible to the naked eye from the surface of the Earth.

Only when giant telescopes were equipped with cameras and sophisticated spectroscopes could the stars in distant galaxies be discerned and analysed. This is why galaxies were not understood to be the objects they really are until the twentieth century. Before then, they were grouped under the heading of "nebulae" (i.e. clouds) and were not readily distinguishable from the vast clouds of interstellar gas found in and around the Milky Way. The spectroscope enabled astronomers to examine the physics of interstellar bodies, with the Doppler effect enabling a determination to be made about the speed of approach or recession. Further information was then derived about the rapidity of galactic rotation and the extent of churning motions within surrounding interstellar clouds, or even the velocity of individual stars in their galactic orbits.

This book abounds with photographs (many in colour) and drawings to illustrate various facets of the galactic scene. It is not a text book in the accepted sense, being written in a light, almost casual, style and — although adequately descriptive, does not attempt to go into physical or technical detail. Rather, its object is to provide an overview of what is probably one of the most absorbing subjects that anyone could wish for. Those unfamiliar with galaxies will find this a most arresting volume. Those already filled with a surfeit of knowledge about them will find it equally enjoyable to look through the attractive range of photographs and to ponder about objects which reach into the vastest recesses of space and time.

Most of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

1984 SUBSCRIPTION FEES

There is good news for UK members: fees for 1984 will remain unchanged from 1983 in spite of rising costs.

Even better news for overseas members who pay in US dollars: the exchange rate means that the 1984 fees are substantially lower than those of 1983.

Direct Debit Scheme

Our old Bankers Order System has now been phased out. Direct Debit slips are available from the Executive Secretary but, as these will not now come into operation until 1985, a separate remittance for 1984 must be made.

Amounts payable for the calendar year January-December 1984 are as follows:

RATES

Members	Sterling	US Dollars
Under the age of 18 years	£16.00	$26.00
Between 18 and 20	£18.00	$30.00
21 years of age and over	£21.00	$36.00
Associate Fellows	£23.00	$40.00
Fellows	£23.00	$40.00

Age Allowance

A reduction of £2.00 ($4.00) is allowed to members of every grade over the age of 65 years on 1 January 1984.

JBIS and *Space Education*

The additional subscription payable for *JBIS*, where required as well as *Spaceflight*, is £20.00 ($34.00). For *Space Education*, it is £4.00 ($7.00).

Methods of Payment

Europe

(a) Please pay in sterling with a cheque which shows a UK address, where it can be paid.

(b) Cheques drawn in sterling on banks in Europe must include £2.00 to defray bank charges and collection costs. Eurocheques have no charges *only* if the account number is written on the back.

(c) Banks which remit directly to the Society must be told to see that the sum is transmitted *free of deductions*.

(d) Remittances from Europe are best made by GIRO. Our GIRO account number is 53 330 4008.

USA and CANADA

(a) US dollar cheques can be drawn on a Bank which gives an address in the United States or in the UK. US dollar cheques drawn elsewhere need to be increased by $8.00 to cover collection charges.

(b) US dollar notes are accepted.

(c) US or Canadian money orders can only be accepted if *expressed in Sterling*. Internal money orders from these countries i.e. those expressed payable in dollars will be returned as they are not cashable in the UK.

(d) Canadian bank remittances may easily be made in sterling drawn on their UK agents. If payment is made in Canadian dollars the current exchange rate may be used, plus the addition of 8 Canadian dollars to cover exchange and collection charges.

JBIS journal of the british interplanetary society

The *Journal of the British Interplanetary Society* has appeared since 1934. Many of today's developments first saw light in its pages. Nowadays it is a 48pp monthly with a worldwide reputation, with each issue devoted to some special aspect of space studies. The annual subscription is £20 ($34). Individual copies cost £2 ($4) each post free. Some recent special issues are described below.

Interstellar Studies

"Red Cover" issues of *JBIS* are published quarterly. These are unique, covering all aspects of interstellar travel, communications and extraterrestrial life. Over 40 separate issues have appeared to date, thus making it the most comprehensive source of reference to star travel now available.

Soviet Astronautics

This is another special once-a-year issue, this time on Soviet space activities. The October 1983 edition includes papers on the Soyuz manned spacecraft, nuclear-powered satellites and cosmonaut histories.

Other Special Issues

Many other special issues are published as occasion demands, e.g. on Space Communications, Halley's Comet, Orbital Dynamics, Infra-Red Astronomical Satellite, Image Processing, etc.

FEBRUARY JOURNAL

The February 1984 issue of *JBIS* is devoted to "Space Technology," with most of the papers originating from the 18th European Space Symposium held at Society HQ in June 1983.

Papers include "The Potential Market for a Low-Cost Launch Vehicle," "The Space Shuttle Solid Rocket Booster Recovery System," "Remote Sensing Missions for the Next Decade," "The Far Ultraviolet Spectroscope Explorer," "The Future of European Communications Satellites" and "Precision Laser Tracking for Global Tectonics."

Copies of January's *JBIS*, devoted to "Halley's Comet," are still available although stocks are being exhausted very quickly.

Copies of any *JBIS* issue can be obtained for £2 ($4), post free, from The British Interplanetary Society, 27/29 South Lambeth Road, London SW8

Back Issues

A list of back volumes, bound and unbound, is available. Single issues are also available. Please specify your requirements, with s.a.e. Reprinted volumes are available from: Kraus Reprint Corp., 16 East 46th St., New York, N.Y. 10071, U.S.A. Microfilm copies can be obtained from: Swets & Zeitlinger, Keizergracht 487, Amsterdam-C, Holland.

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Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01–735 3160

Correspondence and manuscripts intended for publicatio should be addressed to the Editor, 27/29 South Lambetl Road, London SW8 1SZ.

NOTICES OF MEETINGS

Full details on some of the meetings listed below are to be found inside the magazine.

Lecture
Title: **ARTIFICIAL INTELLIGENCE FOR INTERPLANETARY MISSIONS**
by Tim Grant

The first of two lectures by a member of the Daedalus study team on artificial intelligence in space exploration. The second lecture (25 April) considers interstellar missions.

To be held in the Society's Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ on **28 March 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

Lecture
Theme: **EXPLODING STARS**
By A.T. Lawton
President of the Society

To be held in the Society's Conference Room, 27/29 South Lambeth Rd., London, SW8 1SZ on **4 April 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

One-day Symposium
Theme: **SPACE TRANSPORTATION SYSTEMS**

A one-day symposium on the above theme will be held in the Society's Conference Room on **11 April 1984**, 9.30-5.30p.m.

Offers of papers are invited. Potential authors are requested to contact the Executive Secretary at 27/29 South Lambeth Rd., London, SW8 1SZ.

Lecture
Title: **ARTIFICIAL INTELLIGENCE FOR INTERSTELLAR MISSIONS**
by Tim Grant

The second of two lectures by a member of the Daedalus study team on artificial intelligence in space exploration.

To be held in the Society's Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ on **25 April 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

History Meeting
Theme: **BRITISH ROCKETRY DURING THE SECOND WORLD WAR**

A number of contributions will be presented at a meeting on the above topic, which has been arranged by the Society's History Sub-committee. To be held in the Society's Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ on **2 May 1984**, 6.30-9.00 p.m.

Admission is by ticket only. A registration fee of £1.00 is payable, which will also cover the cost of coffee. Members should apply in good time enclosing a stamped addressed envelope.

Lecture
Title: **ASPECTS OF ROCKET TECHNOLOGY**
by Martin Fry
Chairman, *BIS Programme Committee*

To be held in the Society's Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ, on **16 May 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

35th IAF Congress
The 35th Congress of the International Astronautical Federation will be held in Lausanne, Switzerland on **7–13 October 1984.**

Members of the Society wishing to present papers are asked to notify Dr. L.R. Shepherd, Chairman of the BIS International Liaison Committee at Society HQ as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

Space '84
The Space '84 "weekend" will be held in Brighton on **16–18 November 1984.** See inside this issue for details.

LIBRARY

The Library will be open to members from 5.30–7.00 p.m. on the following dates:

28 Mar 1984   4 Apr 1984
25 Apr 1984   16 May 1984

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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CONTENTS

A TIME FOR GREATNESS

Our 50th Anniversary year heralds new initiatives in Man's exploration of the space frontier. In particular, the upsurge of interest in the Space Station must be regarded as a major step in the further exploration of space, to be followed later by lunar bases, mining and manufacturing facilities. Our Society applauds the continuing US initiative in this field and, of course, work in the USSR to establish a manned orbital station capability. There has already been a response from some European countries to the US. So far, this has not been the case as far as the UK is concerned. This is even more regrettable when it is recalled that, just over 20 years ago, this country led the whole of Western Europe in almost every area of aerospace technology and was running third, even if somewhat behind, the two major 'Space Nations.' In fact, it was almost entirely a British initiative that led to the setting up of ELDO and ESRO.

Since that time, the UK has fallen behind. Were it not for private industrial initiatives, which have maintained a worthy position in the spacecraft technology field, and some successes in the pure scientific sectors, our country might even have disappeared from the scene. Governmental sponsorship of space technology has been negligible. Indeed, if one takes account of the sabotaging of ELDO in the late 1960's, it has been negative overall. While the latter owed much to individual prejudice at ministerial level, the underlying cause of the decline in governmental support for space development has been the continuing process of curbing public expenditure. In principle, the cutting of excessive spending in government departments is applied across the board, often in a mindless bureaucratic manner. Only those areas likely to provoke adverse repercussions among the electorate escape the worst deprivations. The inclination to concentrate the most serious depredations upon sectors that involve heavy early investment with relatively remote benefit is inevitable. No government wishes to commit itself, if possible, beyond its present and – hoped for – next term of office. Long range technological and industrial developments of every kind stand out in this respect and come in for frequent savage cuts. Regrettably, nearly all important enterprises in space technology come into this category.

The present Prime Minister of the United Kingdom is professionally qualified in technology and recognises the need for Britain to maintain a high competence in all its fields. There is little evidence so far, however, to suggest that her government is prepared to give adequate support to those technologies that are still so far removed from the market place that they will not reach a state of economic significance until the end of this century, or later.

Continued overpage

COVER

An artist's impression shows the European Space Agency's *Giotto* flying past the nucleus of Halley's comet on 13/14 March 1986. The probe will pass the comet at 68 km/s, forcing the use of a shield to protect the craft from collision with dust particles. Colour images will be relayed *via* the dish antenna (seen pointing down); the small cylinder at the top is part of the TV system. A group of BIS members will have the opportunity in May to see *Giotto* under construction at the British Aerospace division in Bristol. *British Aerospace*

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But these are areas that particularly need the support of governments if they are to flourish when their time comes. It is not reasonable to expect private capital to be injected in sufficient quantities to satisfy such long term requirements. In the USA, whose economy is based mainly upon private capital, the need to support space development with generous public funding has always been recognised positively, as in the USSR with its socialist economy.

Britain is a relatively small country, overpopulated in proportion to its total natural resources, and has depended heavily upon its early exploitation of technology and upon its scientific acumen and flair for innovation. It has now been overtaken by many nations who have come later but fresher into the field. But our community can only maintain its viability if it remains in the forefront in industry. To expect to remain prosperous by trading in the commodities of other nations is almost certainly unrealistic and, in any case, decadent, leading to a society with no motivation and inevitable endless discontent and strife. It is vital that this or any subsequent government of this country recognises the reality of this situation and assesses its implications in terms of future investment.

In the next century, if disaster has not overtaken its population, the material resources of our over-populated planet will have been stretched to the limit. Our descendants will become increasingly dependent upon resources that come from beyond the confines of Earth. It may be almost a cliché to say that space by that time will have become the new frontier of human enterprise, but it is almost certainly true.

If the British community is not on that frontier it may be nowhere. It will only be there if the preparation is made *now*. Of course, the UK cannot proceed in isolation, it must do so as part of an international community in which it is both co-operative and competitive; co-operative in playing its full role in joint enterprises and competitive in ensuring that it enjoys its share of the benefits of success.

If Britain is to play its part in future space activities, it will need a substantial increase in government investment in research and development both in national and international programmes. Almost certainly this will require substantial institutional changes involving the setting up of a single agency responsible, generally, for the organisation of space programmes and funds along the lines of NASA and France's CNES. It is worth noting that, ten years ago, the UK government of the day advocated the establishing of such a body to direct joint Western European projects. This was done on the advice of its own advisory councils and followed years of prodding by the BIS. The UK sponsorship of this concept led to the setting up of the European Space Agency. Unfortunately, the British government did not pursue a similar line within its own borders by forming a single authority to organise the national space activities.

For years, our Society has argued the need for placing UK space activities under a single agency. Instead, fragmentation of governmental involvement in space development has continued along with the inevitable decline of British status in the field. This division of responsibility has meant that cases for particular space initiatives have had to be argued in separate courts, notably within the aerospace, telecommunications and scientific communities. Not only has this weakened the hands of those concerned with our country's overall performance in space technology, but it has contributed to the complete demise of British participation in some vital areas. A particular case in point is that of launching vehicles and propulsion, an area in which Britain, in 1960, was still operating in the top division. Unfortunately, the funds for rocketry had

In her Christmas Day message to the Commonwealth, Her Majesty the Queen dwelled on the importance of space technology at some length, pointing out the benefits it brings to all. TV viewers saw her 'flying' a Space Shuttle simulator during a visit to Rockwell International in California during February 1983. Prince Philip tried his hand and Rockwell observers noted that it was obvious he is a qualified pilot.
Rockwell

to come from the aeronautical research and development budget and compete with much more powerful and firmly established interests in conventional aviation. Rocket propulsion and launching vehicle development accordingly suffered such severe financial restriction that even the UK contributions to ELDO were denied. It is arguable that this would not have happened had there been a separately funded national space agency, able to allocate its own priorities to various aspects of the technology, taking proper account of long term interests as well as those of more immediate application. Without such an agency it is inevitable that only the shorter term developments will be served.

Now we are in a fresh phase in space exploitation and exploration. Ahead lies the establishment of larger orbital facilities, space stations and beyond that lunar bases. Britain, if it is to remain a viable 21st century industrial community, must be able to participate fully in these developments as they come. It will hardly be capable of adapting to this evolving scene unless it is properly organised institutionally to react to each challenge as it arises.

The government's concern must be with the future of our nation as a community with continuing industrial capability. This means capability in space as much as in any other area of technology, perhaps even more.

It must see to it now that we are equipped with the proper means and organisation.

THE SPACE STATION

Announcing Presidential support for the space Station programme in the 1984 State of the Union message may have been the most effective way for the US President to break the existing log-jam, but it was not the best way to convince Europe to participate, because it fuels the argument that the programme is being approved on US domestic political grounds rather than its merits. Head shakers will continue and even increase the frequency of

the horizontal motion. Neither did the Administrator of NASA help when he said – however true it may be – that the biggest justification for the Space Station may well come only after it is in place. European critics and professional wet blankets are already drawing the parallel with Concorde and other costly and unsuccessful ventures into high technology.

It would be a tremendous pity if this were to discourage the UK from taking a professional look at the pros and cons of the NASA Administrator's present offer for Europe to participate in this programme. One thing needs to be made clear: the decision now to be made is not whether the UK will participate in the Space Station development programme, but simply whether we should be meaningfully associated with the in-depth study which NASA is to undertake. The UK can thus determine in advance the amount of its contribution, and the decision on participation in the development programme will fall due only when we have gained sufficient insight into the programme, including the institutional arrangements, to allow a worthwhile judgement to be formulated. This is not the case at present. The European Space Agency's efforts on Space Station, in parallel to those of NASA, have been extremely limited and the UK's contribution minute – about enough to pay for one engineer, compared to the thousand in and around NASA.

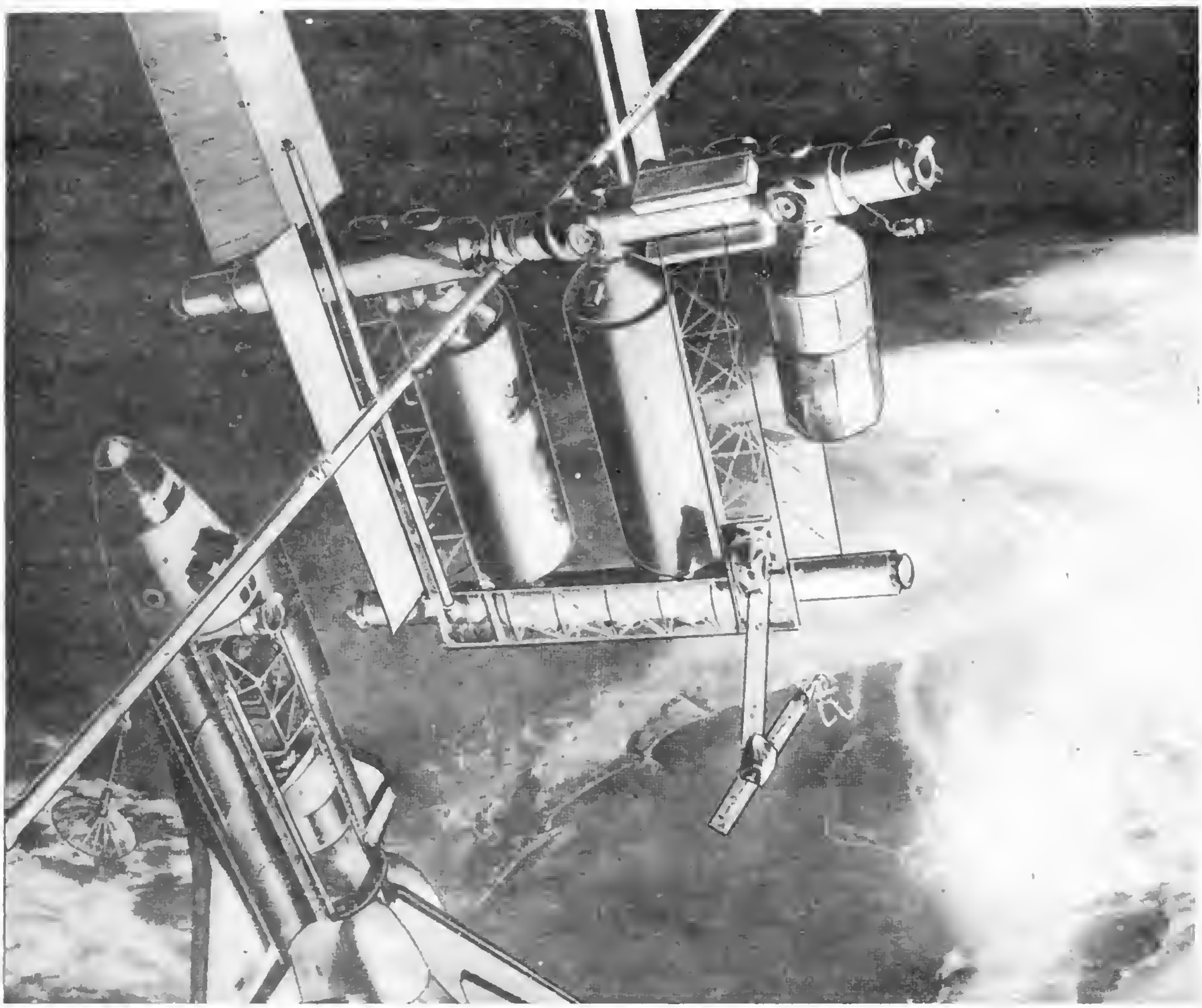
Space Station is quite a different programme from Spacelab; the range of disciplines and technologies involved is many times wider and it includes areas in which the UK is vitally interested. The whole spectrum of information technology – robotics, artificial intelligence, etc – will take a giant leap forward as a result of this programme. The industrial and technological benefits will by no means be limited to the classical aerospace areas.

If we do not have the foresight to take part in this initial phase, we will not be in a position to make a meaningful choice in two or three years (even if the offer were to remain open). Our industry cannot afford from the outside to monitor progress on this vast programme, and it is anyway doubtful whether sufficient visibility would be allowed to non-participants.

NASA is apparently still hoping that the European contribution will be channelled through ESA, and this is clearly the only sensible way to proceed; a series of bilateral agreements with the US only results in less European influence on the programme. The UK should use this occasion to counter the centrifugal activities of other major contributors to the Agency, and win back the political kudos it used to have as a reliable supporter of the many smaller member states who cannot go it alone.

The amount of money involved in participating seriously in the study phase is not large – £10 million ought to be enough – and it would constitute an entrance ticket to a programme worthy of our industrial competence. With such a lead from Government, most major UK aerospace firms would also be willing to make a contribution. The opportunity is truly too good to miss.

Roy Gibson
Former Director-General of ESA



SATELLITES FOR THE SEA

By Derek Webber

The use of geostationary communications satellites for linking continents by radio, TV and telephone is well established. But the use of such links by sea-going vessels is a much more recent feature. The author, financial projects manager of Inmarsat, explains why and describes the advantages of the growing maritime satellite system.

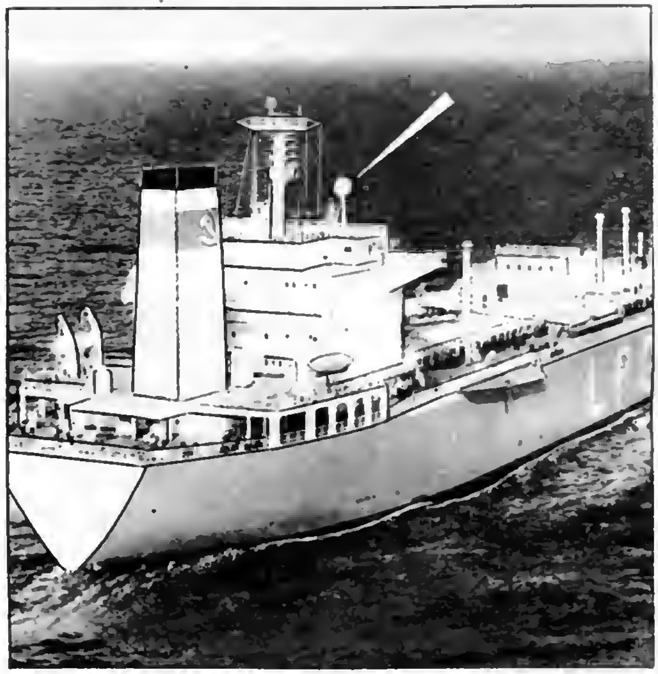
Why Maritime Satellites?

Maritime satellites are needed because the alternative conventional service is so poor. Traditional radio communications with ships at sea using high and medium frequency radio transmissions have major drawbacks. For example, it could take a ship in the South Atlantic about six hours to communicate with its owners in Western Europe. This is because conventional ships' radio relies on multiple reflections off the ionosphere and this process is dependent on the location of the vessel, the state of the Sunspot cycle, the time of day and many other factors. Such delays in, e.g. advising a captain to re-route his ship to pick up a cargo, could represent a substantial cost to the shipowner. The quality of the call using conventional radio is very variable, sometimes bordering on the inaudible. By contrast, communication *via* satellite is instant, reliable and stable.

Also, there is a particular requirement for the instant and reliable qualities of satellite communications for the mariner in distress. Distress and safety communications at sea have traditionally depended on morse telegraphy and radio telephony. Clearly, there are many advantages to a satellite system with links to coast guard and other Rescue Coordination Centre operations. Emergency operations have a much better chance of succeeding if the ships can not only give an instant alert but also notification to the rescue authorities of position, weather and medical information, etc, regardless of their location anywhere on the globe.

Maritime satellites must be part of an overall system in order to operate. The system needs to be global, with the satellites communicating *via* small mobile terminals on the vessels, and a network of large fixed Earth stations located on land. For such a system to be successful, not only must the satellites be operational, together with the supporting network of fixed Earth stations linked into the worldwide telephone and telex networks, but the maritime community must demonstrate its acceptance by a widespread purchase and installation of the ship-based terminals. Clearly, as the number of users increase, the terminal manufacturers can begin to reduce the costs of the terminals, thus allowing the system to grow faster.

Existing ship-based terminals, all of which are of a type designated as 'Standard–A,' provide one voice/data channel and one telex channel. Each installation consists of two components. The above-deck equipment is a dish antenna inside a protective radome (often spherical); the below-deck equipment consists of telephone handset, teleprinter, transmitter and receiver. Operation is as simple as making a normal telephone call on land, in contrast to the approach needed with the conventional radio service where operators must refer to tables of best times and locations for making calls, and a booking system is necessary, often with many hours elapsing between a call being requested and a successful connection being made.



A ship with a Standard A satellite communications terminal.
Skyfotos Ltd

Although the mobile terminals located on the vessels must maintain pointing accuracy despite the vessels' motion, their design is nevertheless much simplified when the satellites used are placed in geostationary orbit. This is the case for existing maritime satellites. Even so, current terminals cost about $40,000 each which, although a small investment for a large vessel (bearing in mind the potential savings to be made). is still too high for some potential users. The costs of future terminal types will be significantly reduced by using higher power satellites and other technological advances making possible a much smaller device than the current 1.2 m antenna.

Historical Developments

We could reasonably ask the question "Why are we only now hearing of maritime satellites?" Maritime satellite development has paralleled that of conventional communication satellites. The rate of buildup of the civilian and commercial use of space in general has been influenced historically by a number of factors, including:

a. the high entry costs and consequential long lead to commercial payback;

b. the fact that governments have until recently controlled the access (through launch vehicles) to space;

c. the uncertainty about the markets which are, by definition, undeveloped.

When we specifically consider the civil use of communication satellites, these problems are further compounded by the need for approved equipment standards and frequencies for international operation. For maritime communications in particular, a whole supporting structure of Coast Earth Stations linked into the terrestrial telephone networks, and full global coverage of the world's oceans was also required. Gradually, over the last 20 years, the conditions have been created that have made the use of maritime satellites a reality.

Some key milestones in this progress have been:

1962 Comsat created by US Government as a vehicle

for using US-developed spacecraft for international communication.

1964 Intelsat formed as international body to offer world-wide satellite communications.

1965 Early Bird, Intelsat's first communications satellite launched into geosynchronous orbit.

1966 International Telecommunication Union (ITU) and International Maritime Consultative Organization (IMCO), began to consider maritime communications by satellite, recognising the potential improvements in safety of life at sea through better communications.

1976 Marisat System introduced by Comsat, as first maritime communication system having an initial two ocean coverage with a ground station on each of the West and East coasts of the USA (for the Pacific and Atlantic Oceans, respectively). Subsequently, a third station was added, in Japan, to link with a third satellite over the Indian Ocean. Three Marisat satellites were launched, on 19 February (Atlantic Ocean), 9 June (Pacific Ocean) and 14 October (Indian Ocean).

1979 Inmarsat came into being as an international body to provide worldwide satellite communications to the maritime user. Inmarsat established standards for terminals.

1982 Inmarsat went operational on 1 February, taking over the Marisat system serving about 1000 vessels fitted with a terminal and introduced many more coast Earth stations. The full Inmarsat first generation space segment, which is all leased, includes the original Marisat spacecraft, Marecs and Intelsat V–MCS in a three region system with in-orbit sparing.

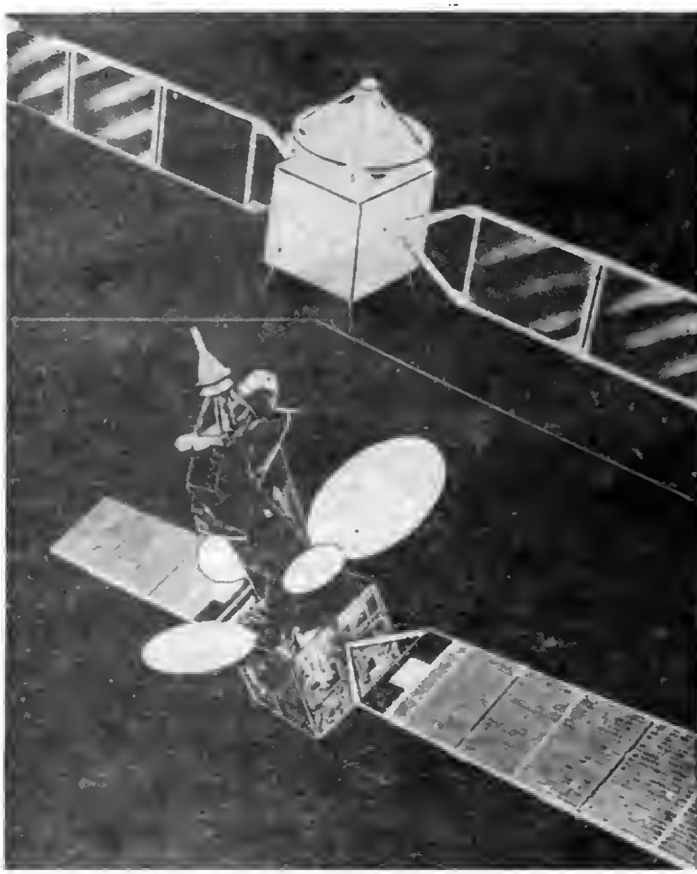
1983 As of November 1983 Inmarsat has 40 member countries, 2100 equipped vessels and eight operating coast Earth stations. A further two stations are scheduled before the end of the year.

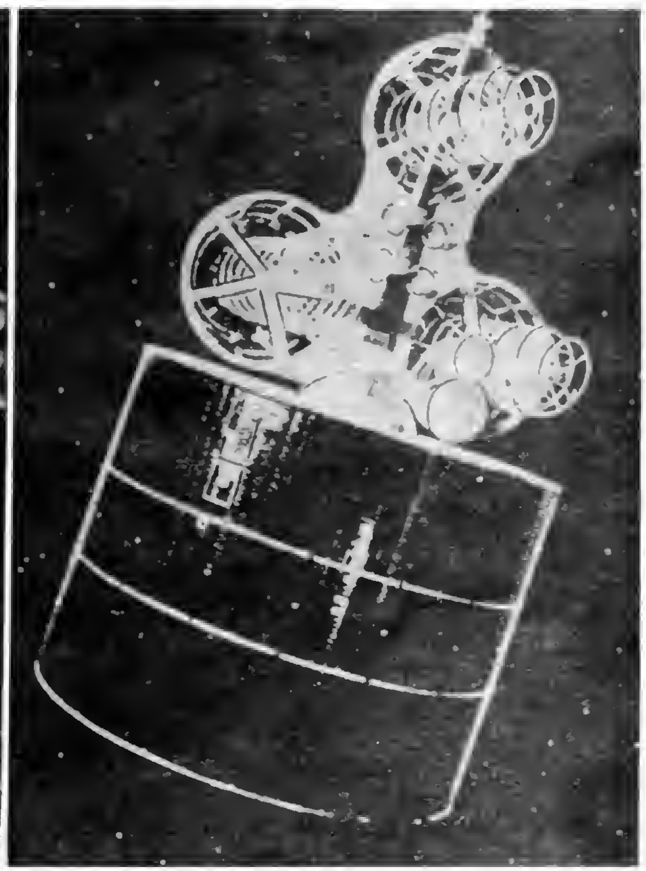
TABLE 1. Summary of Maritime Satellites.

	PRIME CONTRACTOR	ORBITAL MASS	STABILIZATION	LAUNCH VEHICLE	NO. OF EQUIVALENT VOICE CHANNELS
MARISAT	Hughes	326 kg	SPINNER	Delta 2914	8 shore-to-ship 16 ship-to-shore
MARECS	HSD/Marconi	504 kg	3-Axis STABILIZED	Ariane	35 shore-to-ship 50 ship-to-shore
INTELSAT V (F5 to F8) MARITIME COMMUNICATIONS SYSTEM (MCS)	Ford	1003 kg (entire s/c)	3-Axis STABILIZED	Ariane/Shuttle	30 shore-to-ship 30-35 ship-to-shore PLUS SAR and data
INMARSAT 2ND GEN	?	670 kg approx.	?	compatible with more than one launch vehicle of which one must be ARIANE, STS, or PROTON	125* shore-to-ship 125* ship-to-shore PLUS SAR and AERO

*Note: this capacity will be extended to about 200 channels by the use of voice activation techniques.

The three orbiting links in the maritime communications system. *Top left:* the European Marecs satellite, launched by Ariane; *bottom left:* the Intelsat V with its maritime package; *right:* the older Marisat satellite.





Spacecraft Summaries

The Prime Contractors for maritime satellites to date have been Hughes for Marisat, British Aerospace for Marecs, and Ford for Intelsat V, which carries a maritime communications subsystem (MCS) on the later flight models in addition to its channels for non-mobile users. Marisat, Marecs and Intelsat V–MCS are all compatible with the Inmarsat system.

Hughes provided the three Marisat spacecraft during 1976. They also furnished the Intelsat IV A series, and are the prime contractor for the latest generation of Intelsat spacecraft, scheduled for launching in 1986 and designated as Intelsat VI. At the moment, however, no MCS is scheduled to be included on the Intelsat VI series and so their involvement in maritime satellites has been diminishing since the formative contribution.

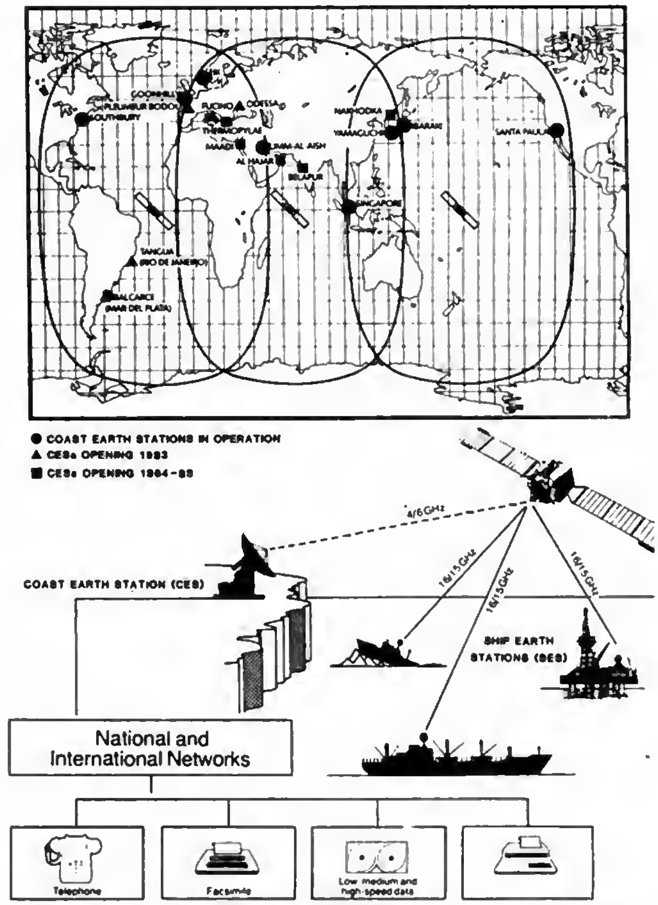
British Aerospace (as H.S.D.) developed the Marecs spacecraft originally from OTS, the orbital test satellite, which was launched in 1977. The maritime version of the test satellite, initially called Marots was planned for a 1979 launch, and ESA undertook to fund it, but the design was changed in 1976 to ensure compatibility with the existing Marisat system, and at the same time advantage was taken of the newly developed European Communication Satellite (ECS) spacecraft platform wjth its extended lifetime. The name was changed to Marecs and the first satellite began operating in 1982 following the first successful commercial launch by Ariane on 20 December 1981. Unfortunately, the second Marecs flight spacecraft was destroyed as a result of the Ariane L5 launch failure in September 1982. A third Marecs is being provided for Inmarsat and is expected to be launched, again by Ariane, in 1984.

Ford Aerospace became involved in maritime communications when they were awarded the contract for Intelsat V. Inmarsat and Intelsat entered into an agreement whereby INMARSAT would lease shared capacity on the later flight models of the V series by means of a special maritime communications system (MCS) added to the spacecraft. MCS's are planned for four Intelsat V spacecraft.

The Table summarises the main features of the maritime satellites. Communications are offered through telephone and telex and high speed data. Inmarsat is currently asking for proposals for its second generation space segment to be available from 1988 onwards, and the Request for Proposals (RFP) was issued to potential bidders on 1 August 1983. The new generation of satellites will be many times larger than the first generation in terms of their capacity. This is because by the time the first generation reaches the end of life, Inmarsat expects considerable growth in demand to have taken place. The second generation system may be leased, like the first generation, or purchased, or be a combination.

Possible Future Developments

Prospects look good for maritime communications. The number of ship terminals in the Inmarsat system has now doubled since the organisation became operational in early 1982. As more terminals are fitted, the manufacturers are lowering their prices. Tariffs for using the system have been falling, too, in real terms. Inmarsat is a commercial organisation and will be pursuing commercial approaches to encourage the growth of the system. Potentially more than 50,000 vessels worlwide are candidates for ship Earth stations (SES). All kinds of vessels currently use the system, with a large percentage (~ 50%) of oil industry utilization. However, 4% of the ship terminals are currently placed on yachts, despite the current relatively large antenna size. New standards are being produced



Top: Inmarsat's global coverage; *Below:* the elements of a maritime communications system.

that will result in much smaller vessels being able to fit an SES. Airliners are also candidates for future smaller terminals. Aircrew on international flights experience for several hours the same communications difficulties as do ships at sea using conventional radio. Satellite communications to such airliners could bring the crews up to date navigation, weather and operational information, perhaps by telex. The passengers, too, like their counterparts on ocean liners, would be candidates for access to a telephone link on long duration flights, provided that satisfactory price levels are achievable. The current RFP process for the Inmarsat second generation space segment includes some provision for use of air band frequencies. Thus the technical problems can be solved and these developments are possible provided that agreement can be reached between the interested parties, such as the International Civil Aviation Organization and Inmarsat.

By the end of this decade, regulations are expected to be introduced by the UN-based International Maritime Organisation (fomerly IMCO) to make satellite communications a mandatory requirement for certain classes and sizes of vessel, as part of the IMO's Future Global Maritime Distress and Safety System. The Inmarsat geostationary satellites could be integrated with polar orbiters to complete the global coverage beyond the ± 70° latitude limits imposed by geostationary operations and allow a full search and rescue and navigation facility to be offered.

The latest spacecraft technology can begin to make these developments possible through such techniques as spot beams for ocean areas of high traffic concentration to augment the main global beams. Since 80% of the world's international trade travels across the oceans of the world, such improvements in safety and navigation, together with efficiency and economics resulting from immediate communications, will surely have a major impact on us all.

CORRESPONDENCE

The Society's Name

Sir, I note that it was mentioned at one of the Society's 50th Anniversary banquets that the BIS took its name from the American Interplanetary Society. With all due respect to the speaker Fred Durant, and although the formation of the British Society was encouraged by the then existing American body, it seems to me that the statement comes under the heading of superfluousness, in that there was little else that such an organisation *could* be called. To which I would add that the BIS certainly did not follow its American counterpart when shortly afterwards it saw fit to change its title by what we considered a retrograde substitution of 'Rocket' for 'Interplanetary'.

But this having been said, I express the hope that we are not on the verge of creating an international incident out of the matter.

P.E. CLEATOR
Merseyside
(BIS founder and first President)

CRRES

Sir, In the January *Spaceflight* Dr. Stephenson said that American space authorities are considering the launch of a Chemical Release and Radiation Effects Satellite (CRRES). In fact, the project has been fully funded by NASA (the chemical releases) and the Department of Defence through AFGL (the radiation effects part, called Spacerad) and is due for launch in June 1986.

The initial orbit is low-Earth (350 km circular, 28.5 deg. inclination) for the chemical releases and a geosynchronous transfer orbit (400 x 35 km, ~23 deg. inclination) for Spacerad.

As well as the space radiation package, the satellite aims to map and characterise the dynamic behaviour of the radiation belts. With this in mind, AFGL are flying a complete range of scientific instruments, including two low energy plasma analysers designed and built in Britain by Mullard Space Science Laboratory.

MARK SMITH
Mullard Space Science Laboratory
Surrey

The Oscar Satellites

Sir, The reference to the "US Oscars" in the *Spaceflight*, December 1983 article "Satellite Radio Tracking for the Amateur" should be clarified. The Oscar series of amateur satellites is not all-American, but international. The first few Oscars were indeed almost entirely funded and constructed in the USA. However, Oscar 5 was an Australian venture by the University of Melbourne. Oscar 9 (Uosat-1) was designed, funded and constructed in Britain by the University of Surrey, and represented a major inovation in educational/scientific satellites. Furthermore, Oscar 10 was led by Amsat Deutschland eV of West Germany, and launched by the European Ariane rocket. Oscar 10 represents another breakthrough allowing, for the first time, reliable long duration intercontinental communications between radio amateurs.

Three more non-American Oscar-type satellites are firmly under way. First, a replacement for Oscar 10 (German again), Arssenne (French), and Uosat 2 (British). The first two will be launched by Ariane 4 in 1985, and Uosat 2 will fly with the replacement for Landsat D on a Delta in February or March. Other countries (e.g. Japan) also have plans.

The various international chapters of Amsat work in close collaboration. They share funding and resources. For example Amsat USA made generous technical and financial contributions to the Oscar 10 project. European Amsat groups have supported the American Oscars.

CHARLES RADLEY
Stevenage

Eclipses of 1984

Sir, Could you tell me what eclipses of the Sun and Moon will take place this year?

HAROLD LARBEY
Manchester

There are five eclipses in 1984 — three of the Moon and two of the Sun. The first is a penumbral eclipse of the Moon on 15 May, when the Full Moon enters part of the shadow cast by the Earth as it orbits the Sun (by definition, lunar eclipses take place when the Moon is full; solar when it is new). A solar eclipse occurs 15 days later and will be visible from Britain and most of North America as a partial eclipse. Two more penumbral lunar eclipses are set for 13 June and 8 November, and a total eclipse of the Sun for 22–23 November (it ends on the 23rd in GMT). It will be visible in the Australasian-Pacific region.

Shuttle Security

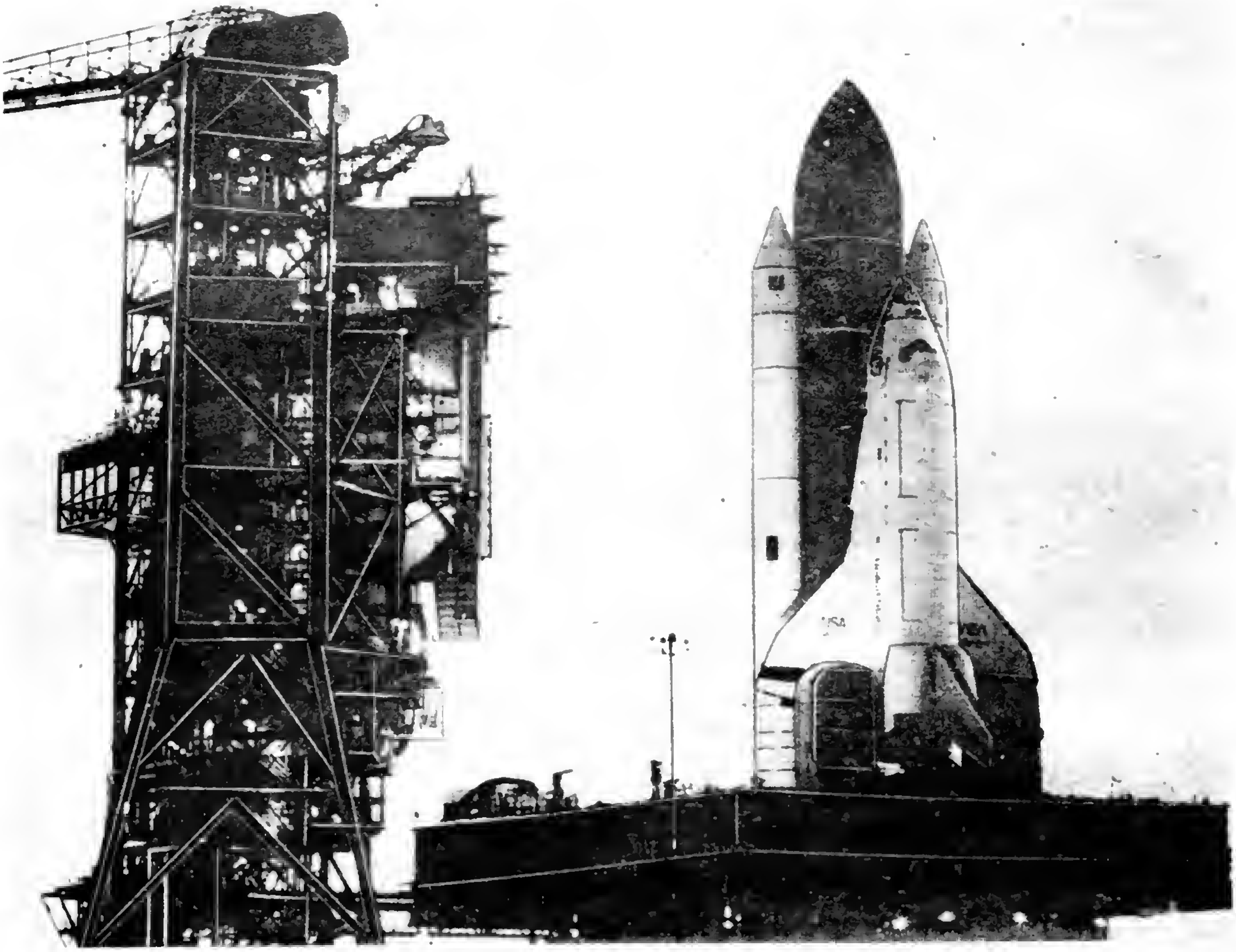
Sir, While the Public Affairs staff at the Kennedy Space Center does an excellent job facilitating the coverage of Space Shuttle launches, a minor impediment has now crept into the previously free access to NASA facilities at Cape Canaveral: security. Access to the Spacelab area of the Operations and Checkout building and to the Vehicle Assembly Building is no longer permitted, even though the printed media guide still lists them. Stops at these sites were part of the press orientation tours during the Orbital Flight Test missions and it is a minor annoyance that reporters may no longer visit them.

Morning and afternoon orientation tours are now hampered by a requirement that reporters stay inside the tour vehicle when in the vicinity of Pad 39A.

On the other hand, the joys of the "sunset tour" and the service structure rollback are undiminished by security

SPACE QUERIES

If any readers have space questions they would like answering — for example, we recently explained why Shuttle astronauts do not wear space suits — then we will do our best to do so. Several queries will be answered in these "Correspondence" pages each issue but please note that *no* personal replies will be made. So please send those letters and start the ball rolling.



Shuttle on the pad: security is important. NASA

regulations. No better view of the Shuttle on the launch pad exists than from the crawlerway directly in from of Pad 39A.

In many ways, the security precautions at the space centre are admirable and desirable. They demonstrate that the American government is serious about protecting the space centre and is prepared for potential trouble. As long as the measures do not further hinder the work of reporters covering the events, the security set up not only can be lived with, but should also be heartily applauded.

JOEL POWELL
Calgary, Canada

The Proton Booster

Sir, A photograph in the Soviet magazine *Sputnik* (October 1983) gives us a hint of the external configuration of the Proton launch vehicle. The photograph appears in a article entitled "Baikonur: Space Travel Centre" by Maj. Gen. Ilya Gurovich and shows a Salyut 7 type station and a base section of a launch vehicle in an assembly and testing building. The two strap-on boosters seen are not conical as those of Vostok/Soyuz launcher but have cylindrical main sections. This supports the conjecture that the Proton has six cylindrical boosters.

IWAO ETO
Tokyo, Japan

Phil Clark replies:

Having discussed the picture with a number of analysts there is a difference of opinion over whether the picture does show the Proton or Sapwood (A-class) launch vehicle. My own feeling is that it does show the Proton strap-ons. If this is correct, then we have seen virtually all of the Proton booster at various times, although a complete picture of the booster from top to tail has yet to be released.

SNIPPETS

Merry Christmas

Sir, Having just received the January issues of *JBIS* and *Spaceflight* I must say that I'm stunned. I know how colour can increase the cost of a publication so I marvel that our Society can produce such magazines.

This is really a good Christmas gift and nothing else is needed to demonstrate the excellent work of all the staff. Thank you for another good year of excellent reading.

FERNAND NOGAL
Lisbon, Spain

My Feelings...

Sir, I feel I must comment on the newstyle *Spaceflight*: UGH!.

DAVE SHAYLER

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

MILESTONES

January 1984

9 *Aviation Week* reports that a new Soviet booster comparable to the US Titan 3 is being readied for its first flight. The new large Saturn 5-class booster is also close to launch from Tyuratam. The Spacelab astronauts photographed the area during their flight last year showing large shuttle buildings and recovery runway.

14 The Japanese GMS-2 weather satellite is replaced in orbit by GMS-1, previously held in reserve because of its age. The scanning mirror motor on GMS-2 is failing and GMS-1, although almost out of fuel, will be used until GMS-3 can be launched in August.

15 It is reported that one of the Giotto Halley's comet probe models has successfully completed electrical tests at British Aerospace (see 'Space Report' for further details).

19 The People's Republic of China has signed a contract with Spar Aerospace of Canada for 20 satellite ground stations, it is announced. The aim is to create a domestic communications satellite system.

February 1984

3 Astronauts Vance Brand, Bob 'Hoot' Gibson, Bob Stewart, Ronald McNair and Bruce McCandless blast off in Shuttle *Challenger* at 13.00 GMT from the Kennedy Space Center for an eight day mission. The Westar 6 satellite is released but is lost for reasons unknown. The balloon for use as a rendezvous target is released on the 5th, but bursts. It was to have been used for practice of the STS-13 mission in April when the SMM satellite will be captured and repaired.

6 Astronauts from the STS-9/Spacelab 1 mission in November/December of last year visit the UK to describe their experiences at a press conference held at the Royal Society. Brewster Shaw (Pilot), Byron Lichtenberg and Ulf Merbold (Payload Specialists), Owen Garriott (Mission Specialist) and Wubbo Ockels (PS backup) are completing a tour of European centres.

7 The Shuttle MMU is successfully tested by McCandless. A further space walk is made on the 9th.

11 Shuttle *Challenger* makes the first spacecraft landing at the Kennedy Space Center.

President Reagan, in his State of the Union message on 25 January, announced that he has approved NASA's proposal for a permanent space station for the early 1990's. The budget of $7491 million (a 4% increase over the previous year) for Fiscal Year 1985 – the year following October 1984 – includes an allocation of $150 million for further station studies, on course for initial operation by 1992. Preliminary design contracts will be awarded in February/March 1985.

The budget, which has to be approved by Congress, also allows for initial work on a Mars-orbiter for launch in 1990.

DO YOU KNOW?

The picture shows a piece of space history. Unfortunately, the astronaut who wore the spacesuit died a few years after the space mission in question here. What was the flight, which two astronauts were involved, and what later space flights did they make?

Answer: this is Edward White's Gemini 4 extravehicular activity suit from June 1965. It is shown emerging from the actual spacecraft, on permanent display at the National Air & Space Museum, Washington, D.C. Note the manoeuvring gun in the suit's right hand. White died in the Apollo 1 fire on 27 January 1967 before he could fly in space again, and James McDivitt, his commander on Gemini 4, flew the Apollo 9 mission in March 1967. Had he lived, White might have been one of the Moonwalkers. *A. Wilson*

DO YOU REMEMBER?

25 Years Ago...
9 April 1959. The seven Project Mercury astronauts are officially presented to the world at a press conference in Washington, D.C.

20 Years Ago...
27 March 1964. The UK satellite Ariel 2 is launched by Scout from Wallops Island on the US eastcoast. The spacecraft returned data for eight months, including information on the interaction of solar radiation with the Earth's ionosphere.

15 Years Ago...
20 March 1969. Test firings of the Nerva-XE experimental nuclear rocket engine begin at Jackass Flats, Nevada. The successful project was terminated a few years later.

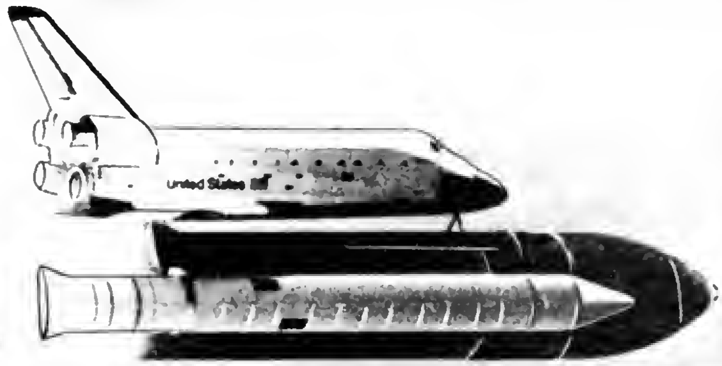
10 Years Ago...
18 March 1974. NASA awards a contract to Morrison-Knudson Company for the construction of the Space Shuttle runway at Kennedy Space Center.
15 April 1974. Soviet Apollo-Soyuz technical specialists, including Soviet prime crew, arrive at the Johnson Space Center for a three week visit.

5 Years Ago...
11 April 1979. Soyuz 33 with Bulgarian research cosmonaut Georgi Ivanov aboard fails to dock with the Salyut 6 space station due to problems with a propulsion unit. The cosmonauts land in darkness the next day.

K. T. WILSON

SPACE REPORT

A monthly review of space news and events



SPACE PROBES

GIOTTO UNDER TEST

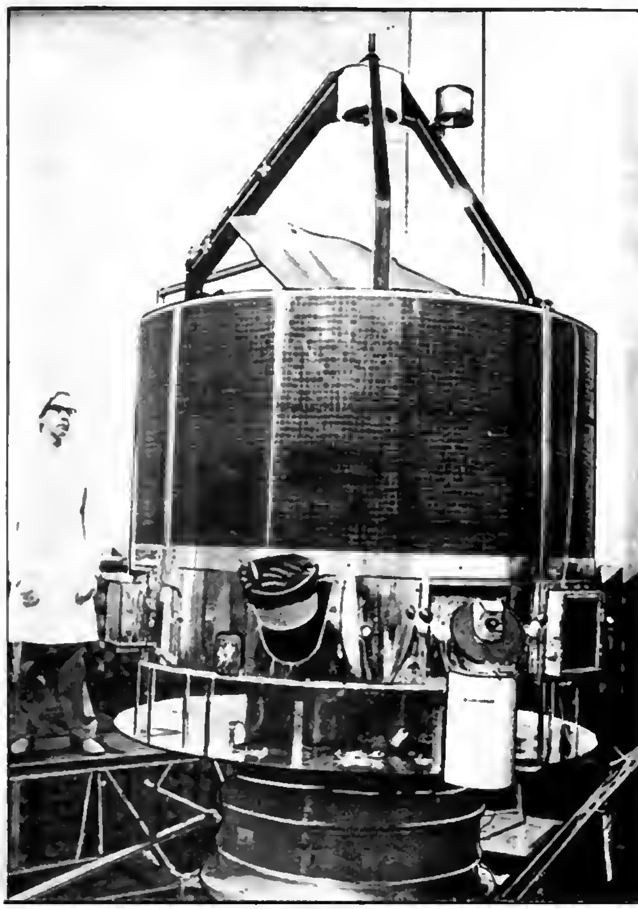
The Giotto probe, due to be launched by Ariane in July 1985 for a flyby of Halley's comet eight months later, completed electrical and electromagnetic interference tests during January at British Aerospace in Bristol.

The electrical engineering model of Giotto is the second version of the craft to be used in the development programme. The first was a structural model which was successfully tested by Dornier Systems in Germany. The flight vehicle is the third and final version, due for delivery next January.

Following launch from South America, Giotto will be released into an Earth geosynchronous transfer orbit. After a few revolutions in this orbit, near perigee, a solid-propellant motor will ignite and the probe will travel in a heliocentric trajectory towards the comet.

Interception will occur during the night of 13/14 March 1986, about one month after the comet's closest approach to the Sun. Giotto is being targeted to pass through the cometary atmosphere (coma) within 500 km of the nucleus, on the sunward side. Allowing for orbital errors, Giotto is expected to penetrate within at least 2000 km of the nucleus.

A party of BIS members will have the opportunity to see Giotto under construction during a visit to Bristol in May.



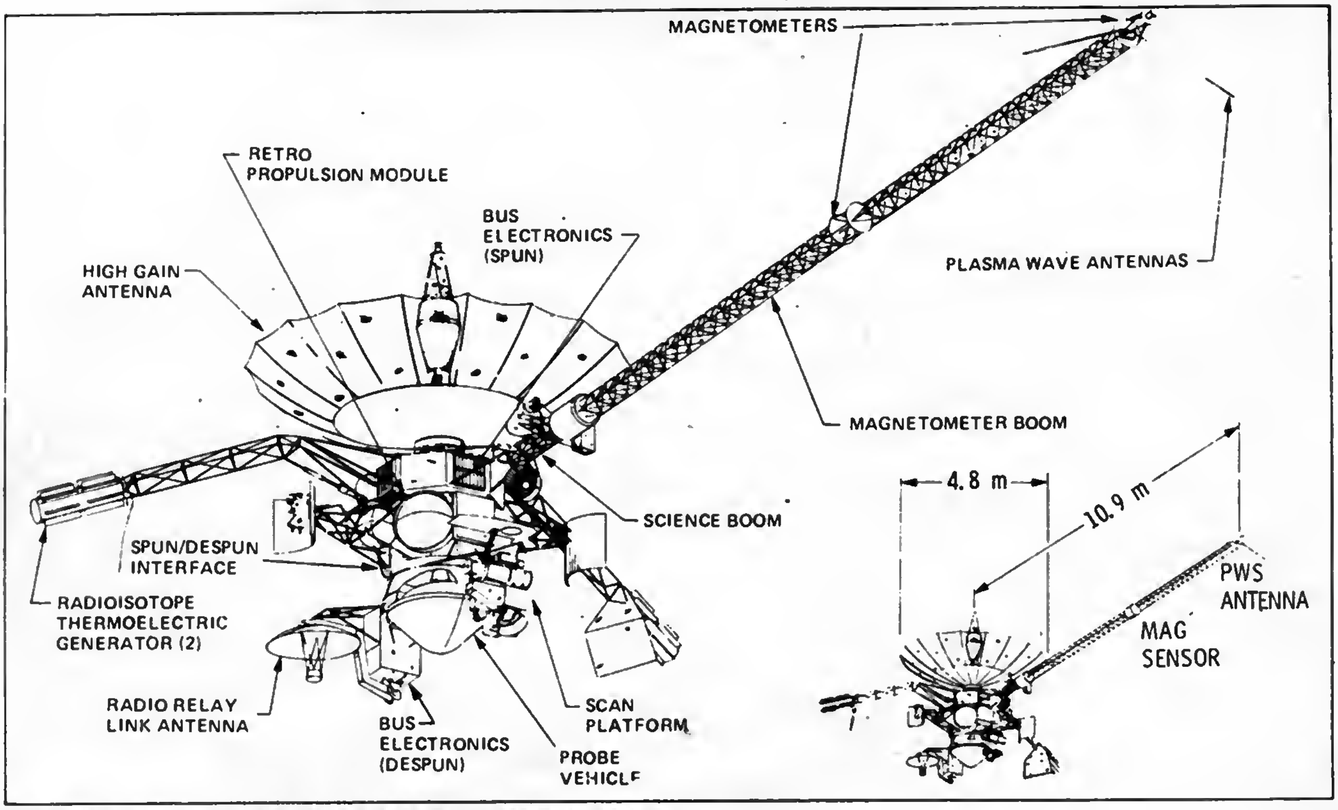
GALILEO ASTEROID ENCOUNTER?

After beating other nations to the first comet flypast by diverting the ISEE-3 spacecraft into the tail of comet Giacobini-Zinner, NASA may be about to pull a cut price mission to the asteroids out of its technological hat. The asteroids are now recognised as priority targets for the next phase of planetary exploration and both NASA and the European Space Agency have asteroid missions under study. Unfortunately, the budgetary famine that has reduced NASA's planetary programme to a shadow of its former self means that the hardware for an asteroid mission may not arrive until towards the end of the century, writes John Davies.

Planetary scientists have recently raised the possibility of using the Galileo spacecraft, which must traverse the asteroid belt *en route* to Jupiter, to conduct a high speed flypast of an asteroid. The Galileo mission is planned to drop a probe into Jupiter's atmosphere then enter orbit to conduct an in-depth study of the Jovian system; launch is expected in May 1986. Depending on the precise launch date, Galileo will fly close to either asteroid 1219 Britta or 1972 Yi Xing and with only small mid-course corrections the spacecraft could make a close approach to one of them. Since Galileo is equipped to study the Jovian moons its instrument package does not require any modifications to investigate an asteroid during such a flyby.

Unfortunately, both of the possible target asteroids are faint and obscure. 1219 Britta was discovered by Max Wolf at Heidelburg in 1932 and Yi Xing was found at Nanking in 1964. Apart from their orbits, little is known about either object — even their diameters are very uncertain. To rectify this, asteroid observers are being asked to study both Britta and Yi Xing to provide a better understanding of them and encourage NASA to attempt an asteroid flypast.

Left: The electrical engineering version of Giotto under test at British Aerospace. The two plates at the bottom (separated by the columns) will act as shields against high-speed dust surrounding the comet – Giotto will fly past at 68 km/s. The white cylinder in the foreground is part of the camera that will provide colour views of Halley's nucleus (the camera itself is safe behind the shields). The upward-pointing cylinder is part of the star mapper used for navigation. *BAe*

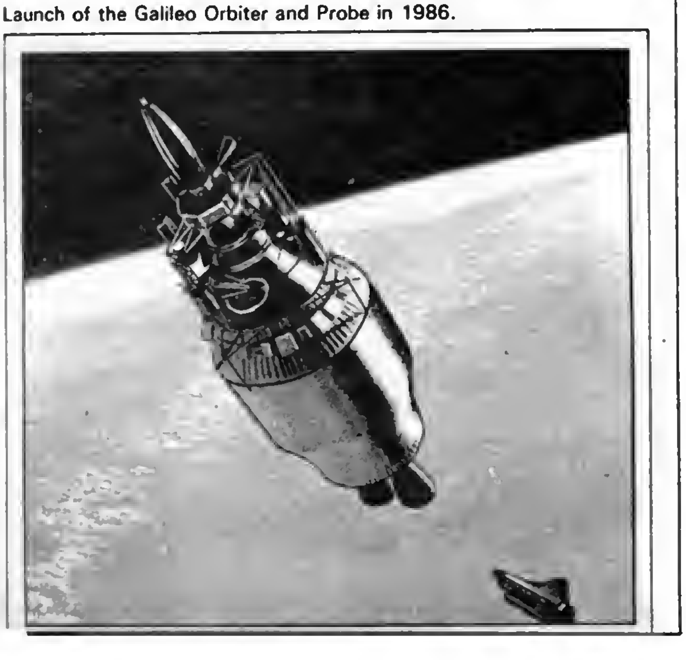


The Galileo spacecraft is already suitably equipped to survey an asteroid.

The measurements needed to fall into several areas. Astrometric coverage of the asteroid is required to improve the understanding of its orbit for navigation purposes, and detailed coverage of the object's lightcurve is needed to establish rotation rate and pole position (for camera targeting). Asteroid diameters are often estimated using thermal models which require accurate measurements of the visible and infrared radiation received from the object. Spectroscopy and polarimetry can provide information on surface composition to assist in interpretation of the photographic coverage.

Using Galileo to investigate just one asteroid is a relatively cheap and easy way to improve our understanding of these tiny bodies. However, two factors may discourage NASA from attempting the asteroid flyby, despite the potential scientific return. When Galileo arrives at Jupiter it is planned to make a number of close encounters with the large Jovian moons. The number of encounters is critically dependent on the fuel available for rendezvous manoeuvres and if mid-course corrections to achieve an asteroid flypast cut too deeply into this reserve, more observations could be lost than gained. Of greater concern is the recent evidence that some asteroids have large satellites. If there are large asteroid satellites, some engineers argue, could there not be clouds of smaller debris orbiting many of the asteroids, and totally invisible from the Earth? A collision with even a small piece of debris could wreck the Galileo spacecraft and wipe out NASA's major planetary mission of the decade. Four NASA spacecraft have flown through the asteroid belt unharmed — it would be ironic if the fifth was actually steered into a disastrous collision.

Launch of the Galileo Orbiter and Probe in 1986.



SPACE VEHICLES

ATLAS CENTAUR

NASA has chosen the manufacturers of Atlas Centaur, General Dynamics Convair, to put the vehicle on a commercial basis. Negotiations for a formal agreement began in January.

President Reagan signed an order on 16 May 1983 encouraging industry to take over launch vehicles. The agency received three proposals by 14 November 1983 disclosing interest in operating Delta and Centaur on a profit basis. McDonnell Douglas builds Delta. NASA proposed that marketing and production of Atlas Centaur might begin in 1984 and launch services following the last government-sponsored launch in 1987.

Atlas was developed by the US Air Force as an intercontinental missile and was used by NASA for Project Mercury orbitial flights. Centaur was developed by NASA as a high powered upper stage for planetary and geosynchronous missions

Astronauts Judith Resnik, Michael Coats and Henry Hartsfield (at right) inspect the large solar array they will be testing in orbit during Shuttle mission 41D in June (see news story). The flight will also see the deployment of Syncom and Anik communications satellites, together with observations using the Large Format Camera and the OAST-1 package. The seven day mission will mark the first use of orbiter *Discovery*.
Lockheed

The first group of female Shuttle astronauts have now all been assigned to missions. From the left of the picture: Rhea Seddon will be aboard Mission 41G (the old STS-16); Kathryn Sullivan will make a spacwalk during 41G (fomerly STS-17) in early September, Judith Resnik will be the second US woman in space, aboard 41D (formerly STS-14) ; Sally Ride — the first US woman to fly, in STS-7 in June 1983 — will go aloft again, this time with Sullivan on 41G to make it the first two-woman space flight ever; Anna Fisher will fly 41H (fomerly STS-18) in September; and Shannon Lucid will be aboard 51A (formerly STS-19) in October. *NASA*

STS-14 PAYLOAD

Perhaps the most spectacular payload on Shuttle mission 41D (formerly STS-14) in June will be the huge array of electricity-producing solar cells under test for the first time. Called SAFE (Solar Array Flight Experiment), the wing was developed by Lockheed for NASA's Marshall Space Flight Center (see picture). It is part of an effort to produce large amounts of electrical power from sunlight in space. The additional power could significantly expand space-based mission operations.

During launch, the accordion-like array wing, 32 m long and 4 m wide, will be folded in the Shuttle's cargo bay in a package less than 10 cm thick. Once in orbit, it will extend to its full length and be retracted several times to verify its operation.

Gary Turner, manager of Solar Array Programmes at Lockheed, says that ambitious projects such as materials procesing, orbiting space stations, scientific experiments and communications activities would require long duration missions with sufficient energy sources.

"Solar array technology opens the door for bigger power supplies that will allow us to perform such important functions in space," he said.

Lockheed's solar array departs from the rigid metal structures currently used on long-life spacecraft. Instead, it is made of a lightweight, flexible Kapton and contains wrap-around contact cells that are welded directly to the array blanket. This printed circuit approach eliminates heavy adhesives and allows greater flexibility during handling and during extension and retraction of the wing.

To minimise costs, the experiment will contain only one wing panel with live solar cells. By contrast, an array with all 84 panels populated with solar cells could convert energy from the Sun to reproduce 12.5 kW.

The experimental wing can generate 66 W/kg compared with 20 W/kg in present systems. With current high efficiency cells, up to 75 W/kg are feasible using the same structural concepts.

McDonnell-Douglas engineer Charles Walker will fly aboard Shuttle mission 41D (formerly STS-14) in June with astronauts Hartsfield, Coats, Hawley, Mullane and Resnik. The entire crew was transferred from the cancelled STS-12. Walker's job is to take care of his company's Electrophoresis Operation in Space equipment — for which he has acted as chief test engineer — in a non-astronaut capacity. EOS, which has already flown aboard the Shuttle, is investigating the separation of materials in space using electric fields to produce purer — and new — medicines. The flight will also mark the introduction of orbiter *Discovery* into service. *NASA*

GETAWAY SPECIAL ART

Artist Joseph Davis of the Centre for Advanced Visual Studies at MIT plans to "paint" an artificial aurora in the sky from the Shuttle in an early mission this year, writes Joel Powell. A 90 kg electron accelerator payload in a Getaway Special (GAS) canister will be used to produce a three minute artificial aurora (limited by the battery power supply) with pulses of electrons. Davis has long been interested in auroral research and began negotiating with NASA to create an artificial aurora from the Shuttle in 1977. The apparatus of this "New Wave Ruby Falls" project, named after a Tennessee tourist attraction, may find use in future serious auroral research.

SPACELAB 4 CANDIDATES

Four scientists were named on 9 January by NASA to train as payload specialists for Spacelab 4, the first Spacelab mission dedicated to Life Sciences, scheduled to fly on mission 61-D in January 1986.

The four are: Dr. Millie Fulford (Veteran's Administration Hospital and University of California, San Francisco); Dr. Francis Gaffney (University of Texas Health Science [illegible]

Bill Williams (Environmental Protection Agency, Oregon).

The group was selected by the Investigators Working Group, consisting of the principal investigators (scientists) responsible for each of the experiments on the mission.

SHUTTLE RADAR DATA

When Shuttle mission 41G — formerly known as STS-17 — takes to the skies next August it will be carrying the SIR-B experiment. Shuttle Imaging Radar-A was carried aloft by STS-2 in November 1981 and produced Earth pictures irrespective of cloud cover, revealing the geological makeup of vast areas. Ancient river beds under the Sahara were exposed, for example.

SIR-B will be able to probe new areas because the mission's orbital inclination of 57 degress will take it over the more extreme latitudes. NASA asked for proposals from around the world for potential targets and six — Britain, Japan, Australia, New Zealand, Sweden and West Germany — of the 44 accepted are outside the US.

New Zealand, for example, has been observed in detail from space only by the Landsat satellite, and there are some areas that remain unrecorded because of persistent

ists because the Indian and Pacific continental plates meet there, producing volcanic and geothermal activity.

A preliminary estimate suggests that the radar data could be worth $10 million to New Zealand alone but NASA will provide it all free of charge with the proviso that full reports are made available to the space agency.

The main purpose of the 41 mission is to deploy ERBS (Earth Radiation Budget Satellite). Kathryn Sullivan will become the first woman to make a spacewalk.

ORBITAL MANOEUVRING TUG

A "request for proposals" has been issued by NASA for aerospace companies' concepts of an Orbital Manoeuvring Vehicle, a "smart space tug" that would move satellites around in orbit. The deadline for initial responses was 14 February; NASA are now selecting several firms for 12-month contracts for studies.

If the government decides to build an OMV, proposed for a first launch about 1990, one of the companies from those involved in the definition studies would build the flight hardware.

The vehicle would supplement the present Space Transportation System, the heart of which is the Space Shuttle. Although the Shuttle has already proven to be an effective ferrying system in moving satellites and equipment to space and back, its limited range of orbital altitude would make the manoeuvring vehicle a valuable addition. As presently envisaged, it will be an unmanned spacecraft 5 m in diameter and 1 m long. It could deliver and retrieve payloads beyond the practical reach of the Shuttle. It could also reboost satellites as their orbits gradually decayed, thus avoiding costly dedicated missions using the Shuttle.

It would be deployed from the Shuttle in the early years for short duration missions; later it would remain in orbit for extended periods as a companion to both Shuttle-based and space station-based missions. Its role in support of a future space station programme is viewed as one of its most valuable attributes. It would be operationally available for the assembly and buildup of an initial station, proposed by the space agency to be built in the early 1990's. It would then become an essential element of station operations.

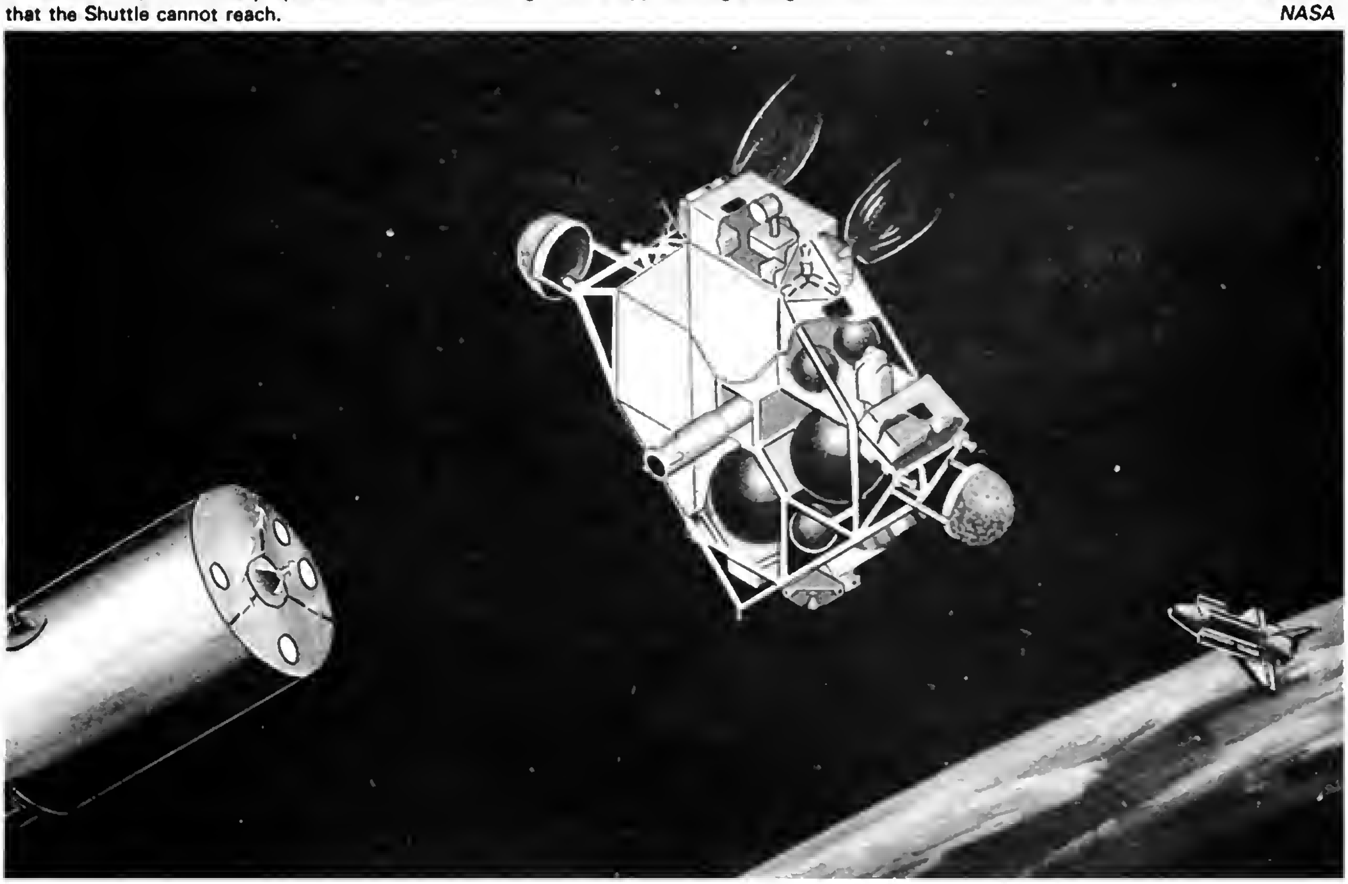
SHUTTLE ENGINE IMPROVEMENTS

One of the most important elements of the Space Shuttle is the cluster of three main engines. It 'burns' for eight minutes to power the Orbiter close to orbital speed and altitude. Each engine is designed to provide a thrust of 170,000 kgf at sea level and be usable for 50 missions with minor maintenance work.

NASA has found, however, that the engines require considerable work between launches, with major items such as pumps being replaced every time.

The space agency plans to spend $1000 million on engine production and improvements over the next 10 years. It appears that contracts will be awarded shortly to Rocketdyne, the manufacturers, to study ways of improving the situation but that more significantly, Pratt & Whitney and Aerojet will be brought in to provide more radical proposals. These two companies bid for the original engine contracts in 1971 but lost out to Rocketdyne. P&W may put forward their 227,000 kgf engine, although only a half-thrust version has yet been tested. Increasing thrust by 33% would allow the Shuttle to carry much heavier payloads, especially an attractive proposal for launches from the California coast into polar orbit.

An artist's concept of the proposed Orbital Manoeuvring Vehicle approaching a target. The OMV will be used to alter the orbits of satellites that the Shuttle cannot reach. *NASA*



The Latest Developments from
Cape Canaveral in Florida

By Gordon L. Harris

STS-9 IN RESTROSPECT

The post-launch meeting for STS-9 astronauts and media representatives elicited two items of interest: Commander John Young's strong hint that he would not fly again and Ulf Merbold's statement that ESA got less than it should have from NASA in their Spacelab pact. He said the terms are "not very good" for ESA. A physicist of the Max Planck Institute, Merbold pointed out that European scientists must pay for any future accommodations on Spacelab 1, built by ESA at a cost $1,200 million. "With this balance, politicians will not be able to sell European cooperation in the future," he added.

STS-9 turned out to be a 10-day mission, the longest yet flown by a Shuttle, and highly praised by experimenters involved in Spacelab 1. *Columbia* had not flown for a year during which new main engines were installed, its structure was strenghtened to support the 17 tonne Spacelab and other modifications introduced, such as accommodations for a six-man crew. So it was with surprise that newsmen learned the Orbiter encountered serious troubles, the anomalies becoming known little by little over a period of days after the landing in California.

The first problem became known when Commander John Young, during the ninth day, fired thrusters to begin reentry manoeuvres. A jarring bang rocked *Columbia*, Young reporting it sounded like a "howitzer blast in your backyard." Instantly Computer No. 1 shut down. No. 2 took over but after four minutes, when thrusters fired again, it also stopped functioning. Nor was this the first computer failure: the STS-1 liftoff was delayed in 1981 by another.

Mission Control shut down Computer No. 3 as a reserve and directed No. 4 to manage environmental systems. A fifth computer remained on standby. Said Young, "When the first one went, my knees shook. When the second went, I turned to jelly." Mission Control managed to revive No. 2 but No. 1 remained silent. Young was directed to continue in orbit while Houston tried to pinpoint the failure. For seven hours and 50 minutes before touchdown, controllers worked frantically.

Young manned the controls for almost nine hours without rest and turned them over to Brewster Shaw. As Young rested, one of the three inertial measuring units broke down. As *Columbia* continued to orbit, its final pass brought it only 130 km above eastern Siberia near the Sakhalin Peninsula. Young resumed piloting and achieved a brilliantly executed landing, whereupon Computer No. 2 shut down again.

The most critical problem, unreported by press for some days, occurred two minutes before touchdown when fire broke out in a rear compartment housing auxiliary power units that energise the ship's hydraulic

The European Space Agency's Spacelab module installed in the cargo bay of NASA's Shuttle Orbiter *Columbia*, showing that the laboratory and its external pallet of experiments occupied little more than a half of the available space. The astronauts, working shifts in two teams of three, moved from the Shuttle cabin to their work stations through the long tunnel. The next Spacelab flight is set for this November.

occurred. Both fire and explosion were unknown to the crew.

Spectators at the site noticed yellow flames alongside the leading edge of the tail. A NASA representative brushed it off as routine. Next day, when a panel was removed technicians discovered the area was scarred and blackened by flames and smoke. APUs burn hydrazine and it was assumed some of the fuel leaked onto hot

After *Columbia* (Spacelab aboard) was flown back to Kennedy Space Center on 15 December the APUs – which have troubled earlier missions – were removed and returned to their manufacturer for analysis. NASA announced an investigation.

When *Columbia* was towed off the Edwards Air Force Base runway after landing a wheel brake locked – a similar failure occurred in June. The component was also removed and shipped back to its source for analysis.

Newsmen criticised the agency for keeping word of the fire and explosion secret until four days later. David Garrett, NASA spokesman in Washington headquarters, said he did not know of the fire although he was at the landing site. Garrett first learned of the situation three days later and delayed releasing information overnight until he had more details. KSC news personnel said their first knowledge came not from Washington but from reporters seeking details

A post landing press conference was held at the Johnson Space Center 8 December 1983. Taking part were Lt. Gen. James Abrahamson, NASA Associate Administrator for space flight; Dr. Burton Edelson, Associate Administrator for Science and Applications, and Michelle Benjeau, ESA director of space transportation. Extracts from JCS's transcribed remarks by Dr. Edelson provide an early appraisal of the results.

"In two areas: life science and microgravity science, we have created new scientific fields. With 15 life science experiments and 30 microgravity experiments we've really created new fields.

"In space plasma physics we've entered into an experimental area of active plasma physics. Using the SEPAC experiment we injected charge particles into space.

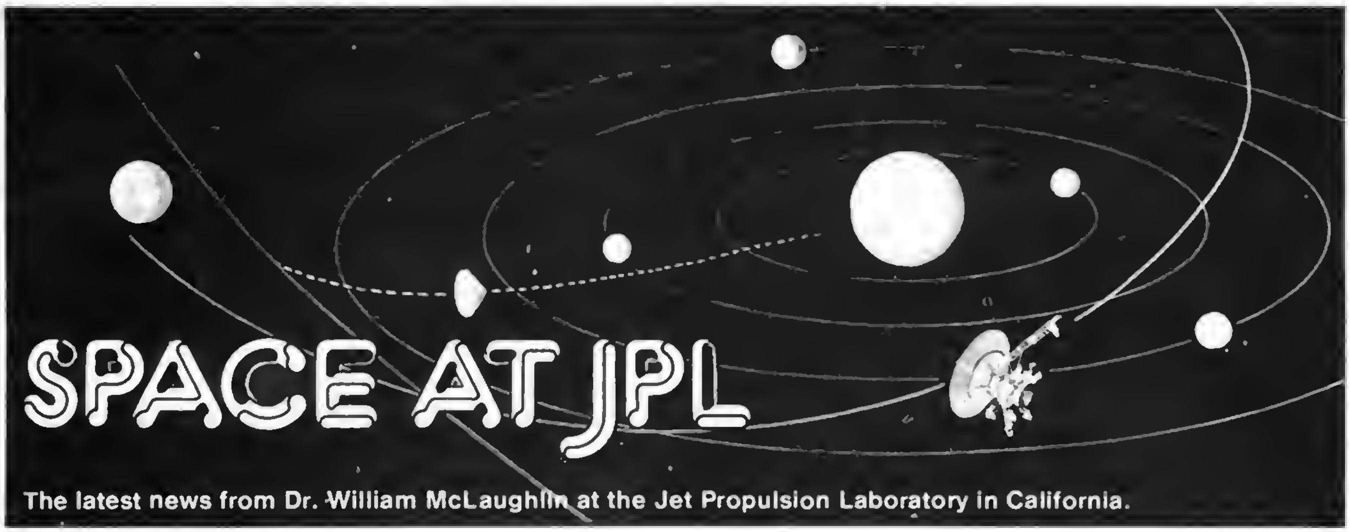
"In other areas: astronomy, Earth observation, atmospheric physics we showed that science can be done in short periods. This mission carried very large, powerful and heavy instrumets with lots of power. For example, the imaging spectrometer is a mammoth and extremely powerful instrument. The principal investigator, Dr. Marsha Torr, said: 'it would do credit to any laboratory to take this marvellous instrument with a capability of going from infrared all the way through the optical to the ultraviolet and make these continuous across the electromagnetic spectra...' This is also a cost effective way of doing it.

"Many instruments will be modified and flown again and again. Spacelab 3 will be dedicated to life science and microgravity in November 1984. We will never again have a mission as complicated as this with as many different experiments. I'm sure we'll get a lot of clamouring from the scientific community to fly in the future.

"Just before the end of mission we went to 38 scientific teams and asked each principal investigator to rate his results as completely or highly successful. Some rated it more than 100 per cent because they got more than expected. In astronomy and solar physics, of six experiments, every one was highly or completely sucessful. The same goes for plasma physics: six successful. In atmospheric physics and Earth observations five of six highly successful, the sixth was radar which burned out his transmitter. In life science 15 successful, one partially so and in materials science we had four facilities."

On a rather different note: NASA also confiscated souvenirs from the flight: postage stamps, love notes and snapshots from six Purdue University students involved in a "getaway special" experiment aboard *Challenger*. The momentoes were concealed under a battery box. The agency discovered the prank when investigators found a student attempting to sell some of the stamps at KSC's public visitors centre.

Shuttle Orbiter *Discovery* is the third spaceworthy craft of the fleet to be completed; only *Atlantis* remains to be delivered at the end of this year. Here, *Discovery* is being towed into the Vehicle Assembly Building at the Kennedy Space Center – it should make its first space trip in June. It is also planned to make the first flight from Vandenberg Air Force Base in California in about 18 months. Note that *Discovery* is missing its three main engines and the two pods with the smaller manoeuvring engines. *NASA*



SECOND VEGA-CLASS SYSTEM

A second star encircled by cool, solid material like that discovered around the star Vega (see "Space at JPL" in the December 1983 issue) has been found in data from the Infrared Astronomical Satellite (IRAS). The discovery was announced after operations of the satellite and its 60 cm telescope had ceased; it was cyrogenically cooled from 26 January to 22 November last year before the supply of liquid helium was exhausted.

The star is Fomalhaut, the brightest in the constellation Piscis Austrinus, the "Southern Fish." Fomalhaut is one of the 20 brightest stars in the sky and lies about 22 light years from Earth. Spectroscopically it is classed as an A type star, as is Vega. The Sun is G type.

Like the material around Vega, Fomalhaut's matter is at least the size of grains of sand. It is not possible to tell from the IRAS data whether or not there are planetary-sized objects (nor with Vega).

The name "Fomalhaut" is derived from the Arabic and signifies "The Fish's Mouth." In the mellifluous words of Garrett P. Serviss (1908), Fomalhaut becomes another sort of symbol, "Flaming above the southern horizon on a chilly autumn night, it attracts a degree of attention that would not be paid to it if it occupied a place in some richer region of the sky. It is like a distant watch-fire gleaming in the midst of a lonely prairie."

Despite the lack of any direct link between the Vega and Fomalhaut systems and planetary-type systems, it is clear that these discoveries have increased expectations that solar systems other than ours exist. One technical perspective on the subject that will be familiar to readers of the *JBIS* "Interstellar Studies" issues is the added information these discoveries may provide with respect to the so-called Drake equation. That venerable formula has frequently been used to estimate the number of civilizations that might inhabit our Galaxy. Numerical values for six of the seven multiplicative factors in the Drake equation are unknown (the rate of star formation is the exception). However, the Vega/Fomalhaut results could eventually yield a better estimate for the factor than quantifies the fraction of stars which have planetary systems, if theoreticians can establish a link between the existence of orbiting material and the likelihood of planets. What the effect of such a link would mean for the probability of the existence of extraterrestrial intelligence is a question whose answer is of first-order importance to students of SETI (search for extraterrestrial intelligence).

IRAS is managed by the Jet Propulsion Laboratory for NASA's Office of Space Science and Applications.

NEW JPL DEPUTY DIRECTOR

With the retirement of Lt. Gen. Charles Terhune, (USAF, Ret.) on 31 December as Deputy Director of JPL, Robert Parks has taken over the Laboratory's number two post.

Parks, who had held the job of Associate Director for Space Science, has been with the Laboratory since April 1947. During this time he has played a leading role in most of JPL's significant projects. His responsibilities have included Mariner 2 (Venus, 1962), Rangers 7, 8 and 9 (Moon), Mariner 4 (Mars, 1965), the Surveyor lunar-lander series of spacecraft, Mariner 5 (Venus, 1967), Mariners 6 and 7 (Mars, 1969), Mariner 9 (Mars, 1971), Mariner 10 (Venus and Mercury, launched in 1972), and the Voyager project to Jupiter and Saturn (launched in 1977).

Before becoming Associate Director, Parks was Assistant Laboratory Director for Flight Projects and, before that, JPL's Planetary Program Director. Before he became Planetary Program Director, he was chief of the Laboratory's Guidance Division and programme director for research and development on the US Army's Sergeant missile. He also worked on the guidance system of the earlier Corporal missile.

Parks was born in Los Angeles, California in 1922 and graduated from the California Institute of Technology in 1944 with a degree in electrical engineering.

Terhune retired from the US Air Force in 1969 and joined JPL in July 1971. As Deputy Director he has functioned as general manager of JPL, responsible for the day-to-day management of the Laboratory's resources and the direction and coordination of its technical, administrative and service activities. He received the NASA Distinguished Service Medal in 1982.

Robert J. Parks, a pioneer in planetary exploration, was recently appointed to the number two job at JPL: Deputy Director

MOVING ABOUT ON THE MOON

In the July/August "Space at JPL" the problem of achieving mobility on Mars was discussed. The proposed solution was an automatically-piloted aircraft which could conduct widespread investigations radiating from the original landing site of the host spacecraft. For this month's advanced-concept review we touch upon radiative mobility on an airless body such as the Moon.

During the Apollo project the last three lunar landing missions used a Lunar Roving Vehicle (LRV) for excursions away from the Lunar Module. The LRV used on Apollo 17 had a total payload allowance of 454 kg: a two-man crew plus 91 kg for experiments, tools and surface samples. The maximum range of this Boeing-built vehicle was 60 km. During the Apollo 17 mission the LRV logged 33.5 km on three trips, with the longest over 18.9 km.

A second solution to the problem of lunar mobility was provided by the Soviet's Lunokhod 1 and 2 unmanned vehicles which were deposited on the Moon by Lunas 17 and 21, respectively, in the early 1970's. The 840 kg Lunokhod 2 travelled 37 km over the Sea of Serenity from January to July 1973 conducting various scientific experiments.

Reaching back into the past a third time for clues to what the future might hold, I spoke with John Beckman concerning a Lunar Flyer vehicle which had been considered for use on Apollo. Today, Beckman is the manager of JPL's Mission Design Section (which among its activities participates in the planning of the Laboratory's advanced projects); during the Apollo era he worked as an engineer on a study of a rocket-propelled platform for lunar travel.

The crewman would have stood on the platform and navigated the vehicle by visual sightings, without benefit of automatic sensing devices, although markings to assist in optical triangulation were to be scribed on a see-through plexiglass sheet. The crewman would have controlled the propulsion system by a hand throttle and would actually have steered by moving about on the platform, changing the location of the vehicle's centre of mass with respect to the rocket's fixed direction of thrust.

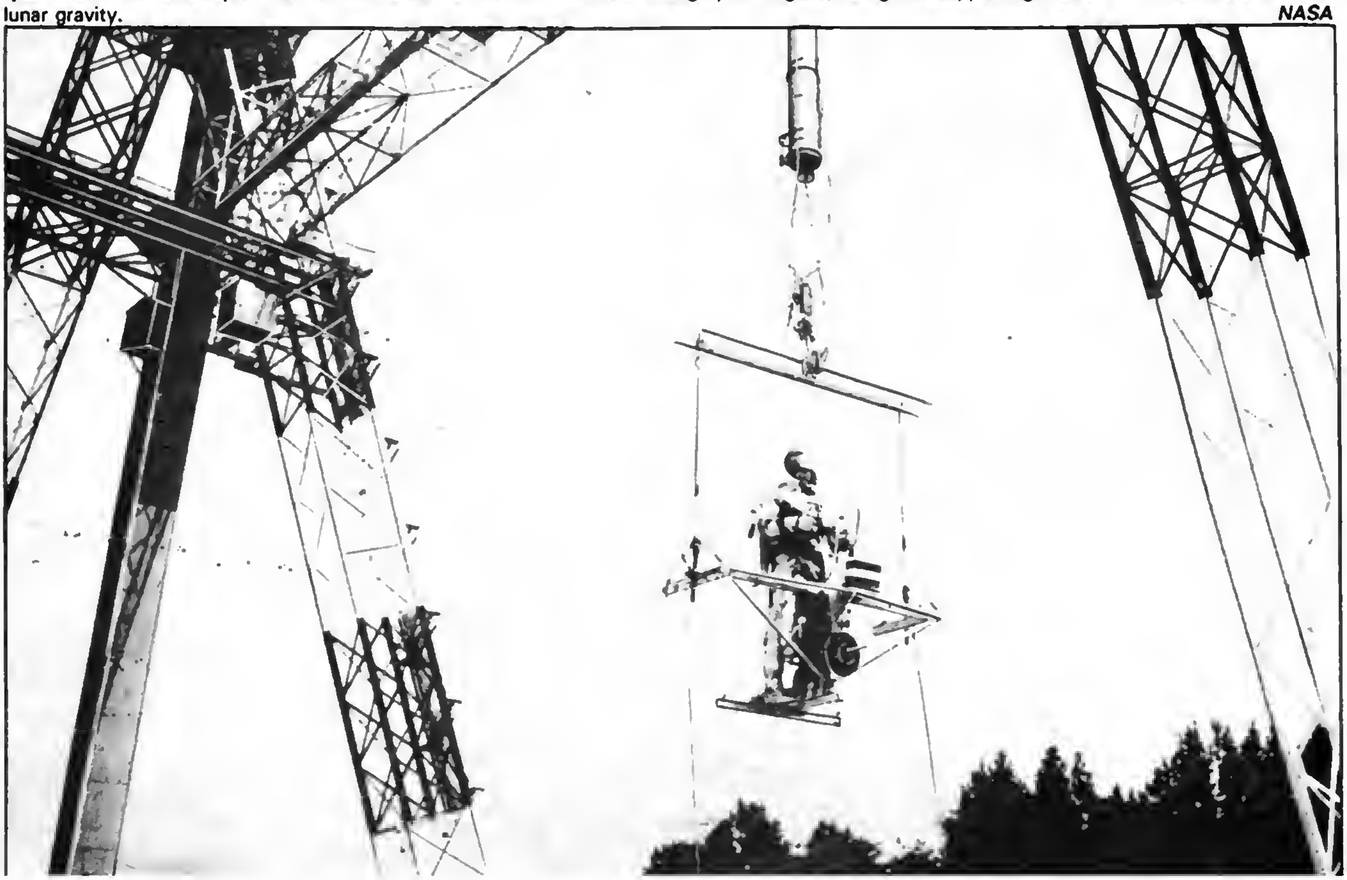
Beckman said that stability of the Lunar Flyer was one technological challenge. Another was the difficulty that would have been encountered in navigating the vehicle on its flights of approximately 10 km. The navigation problem was analysed by constructing a computer simulation of the system and then allowing various pilots to try their skills. Beckman himself never mastered the vehicle to the extent of being able to pilot it about the simulated lunar surface at will. The best results were obtained by a pilot who had had previous experience with flying backpack thrusters, but even he could not attain full control of the system and its need for an intuitive grasp of very complex dynamical relationships.

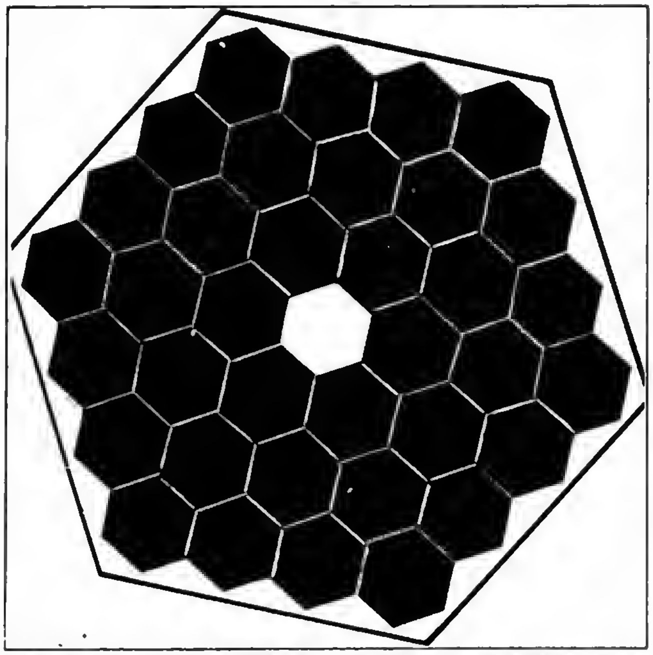
Beckman thinks that a vehicle of this type would function well in support of some future lunar base, serving as a kind of "vacuum helicopter," but that an automatic guidance system controlled by microprocessors would be more effective than purely human control. The Lunar Flyer, together with rovers and the ancient art of walking, would contribute to a balanced system of transportation on an airless world.

TEN METRE TELESCOPE PROJECT

Gerald Smith was the JPL project manager of IRAS during the critical period from 1981 to June 1983. Following this assignment he moved on to become project manager for the University of California's Ten Metre Telescope (TMT) project. The TMT is not connected with JPL, but in addition to drawing upon the services of Smith (now attached to JPL's parent organisation, Caltech) it should use some of the IRAS results to guide the infrared

This lunar surface transport device was tested in the mid-1960's at Langley in Virginia, using the supporting framework to simulate the low lunar gravity. *NASA*





The primary mirror of the University of California's Ten Metre Telescope will be composed of 36 separate 1.8 m hexagonal mirrors.

portion of its observing when it becomes active in 1988.

In order to build a telescope mirror of this size, twice as large as the primary (main mirror) of the Hale telescope at Palomar, a new technology is required; construction of a large mirror using a single piece of glass poses weight, cost and thermal-inertia problems. Two technologies are currently being used to circumvent these problems of scale, yielding: multiple mirror telescopes (MMT) or segmented mirror telescopes (MT). The MMT was referred to in last month's "Space at JPL;" the SMT approach has been selected for the University of California's TMT.

The TMT primary mirror will be a lightweight, monolithic structure formed by a honeycomb of 36 hexagonal mirrors, each 1.8 m in size (the MMT technology employs separate, non-contiguous mirrors). In order to ensure the accurate parabolic surface required of the primary mirror, each of the constituent mirrors will be supported by a real-time positioning system, controlled by microprocessors.

The TMT project started about three years ago with the work of Dr. Jerry Nelson of the Lawrence Berkeley Laboratory. The technology demonstration phase, supervised by Nelson, is now approaching its successful completion, and Smith and his associates are beginning the design and implementation phase.

The TMT, which should be the largest telescope in the world at the time of its "first light" in 1988, will be situated at 4100 m altitude on Mauna Kea in Hawaii. There it will join four other major telecopes at one of the best observing sites on Earth. One of these telecopes, the 3 m Infrared Telescope Facility (IRTF) of NASA, was Smith's last project before his work on IRAS. With the Ten Metre Telescope to follow his accomplishments on IRTF and IRAS, Smith will be qualified to enter the select group of telescope builders such as Brashear, Clark, Ritchey, Porter and Hale who have brought us the raw material of all good astronomy: more photons.

EXTRATERRESTRIAL INTELLIGENCE

Does extraterrestrial intelligence (ETI) exist and, if so, are we likely to contact it soon, eventually, or never? Much has been written on these questions, and two schools of thought are currently focusing on the prevalence of ETI. One school claims that we are alone in the Galaxy (see "Is Mankind Unique?" by A.R. Martin and A. Bond in *JBIS*, May 1983). The other school claims that there is abundant life in the Galaxy; some of the arguments for this position are put forth in "Human Evolution in the Age of the Intelligent Machine" in the December issue of *Interdisciplinary Science Reviews* by your correspondent. At issue are items such as the correct interpretation of the observed lack of extraterrestrials on Earth ("If they exist, where are they?") and the origins of life itself.

The subjects that are being addressed are so fundamental that modern discussions on ETI bear some resemblance to the dialogues that took place in classical Greece on the place of Man in the Universe. Thus, it seems appropriate to introduce the Delphi method into the debate and, to this end, I have polled a group of my associates at JPL for their opinions. Of course, the results of the poll cannot be extrapolated since the sample was biased, being drawn exclusively from the group of associates of a confessed pluralist. Nevertheless, it does represent at least a microclimate of opinion and I reproduce the results here. The percentages are based upon 37 responses to the poll.

1. Do you believe that extraterrestrial intelligence (ETI) exists or has existed? Here, "intelligence" refers to a level equal to or greater than that of a human.

   86% : Yes
   11% : No
   3% : Insufficient information to answer

2. If your answer to Question 1 is "yes," do you believe that ETI is a relatively common phenomenon? That is, would you expect it to have originated independently in a thousand or more places in our Galaxy of 10^{11} stars?

   73% : Yes
   24% : No
   3% : Insufficient information to answer

3. If your answer to Question 1 is "yes," do you expect us to ever contact ETI by radio signals or other means?

   76% : Yes
   18% : No
   6% : Insufficient information to answer

4. If your answer to Question 3 is "yes," when do you expect first contact to occur?

   6% 20th century
   47% 21st century
   9% 22nd century
   16% 23rd century or later
   22% Insufficient information to answer

The relatively small percentage of respondents who failed to answer "yes" or "no" to questions is undoubtedly due to the fact that I asked them to interpret the questions probabilistically, e.g., "if you believe that there is a 50% chance at least one ETI exists or has existed somewhere in the universe, mark 'yes.' If not, mark 'no'. One respondent pointed out that there was some ambiguity in the first question in that a theological "yes" might be appropriate, dependent upon an individual's belief. Another noted that the Apollo astronauts would qualify. When asking the question I had in mind the existence or lack thereof of Little Green Men.

What do you think?

A HELPING HAND

By John Bird

The Shuttle's robot arm is a vital part of its versatility in orbit, allowing it to release, capture and manoeuvre satellites. *Spaceflight* contributor John Bird went to see the place where they are built and meet the men who produce them...

Introduction

From inside the Space Shuttle cockpit we could see back into the large open "cargo bay" through rear windows, while we controlled a 15 m robot arm. I watched the instruments telling us the exact position of the arm's hand and its "end effector". It moved slowly toward a target floating in front of us.

No, we were not in orbit high above the Earth but in a Shuttle cockpit simulator. We could control the arm just as the astronauts do. The arm, or Remote Manipulator System, is Canada's contribution to the US Shuttle and is made by Spar Aerospace of Toronto. I recently toured their testing and simulation facilities with the manager of operations, Jim Middleton. He first showed me their huge "clean room". It is like a gymnasium but it is dust free and is used to test the arm on a frictionless air cushion rig. This allows the arm to move freely, as it would in space.

Technicians in the clean room were preparing to test one of the three more arms that have been ordered by NASA. They will be used on the new Orbiters, and sold to NASA for $25 million each. "But the research and development costs, as well as the hardware for the first arm, were donated by Canada," Mr. Middleton explained.

Touring the Simulator

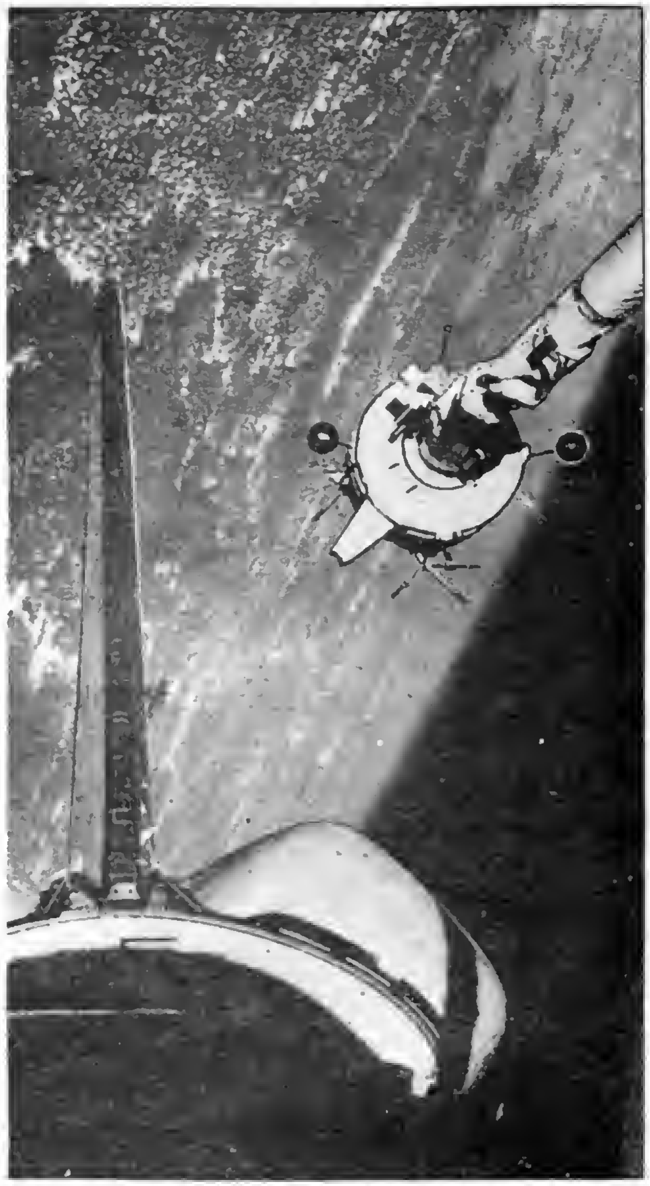
He then took me to Spar's simulation facility, called "Simfac". It is a full scale model of the Space Shuttle cockpit that duplicates the RMS controls. Inside, there was a view of the arm on one of the two television screens with three-dimensional images simulating the Shuttle windows. A special lens behind the window made the image change as I moved my head to look at the Orbiter from different angles.

Two other screens beside the main control panel, showed us the view the astronauts have from TV cameras mounted in the cargo bay. Another camera on the end effector (the part that does the actual grasping) gives astronauts the view they would have if they were out on the end of the arm. This allows them to lift satellites from the Orbiter and put them in their own orbit. To bring a satellite back to Earth, the Shuttle manoeuvres to a position where the arm can reach it, and then the arm can grapple it and place it in the cargo bay.

Other uses for the arm include close inspection of satellites or even the Orbiter itself, using the TV camera on the arm. Large structures such as space stations will partly be constructed in space by astronauts working with the arm. The procedures are being developed on a full-scale underwater Shuttle model.

If NASA decides to improve the Orbiter's construction capability, there are provisions whereby a second arm can be attached. But the Orbiter's computers can handle only one arm at once.

The banks of computers that run the simulator give an idea of the complexity involved in controlling the arm. Consider a human arm. Every time a human arm reaches



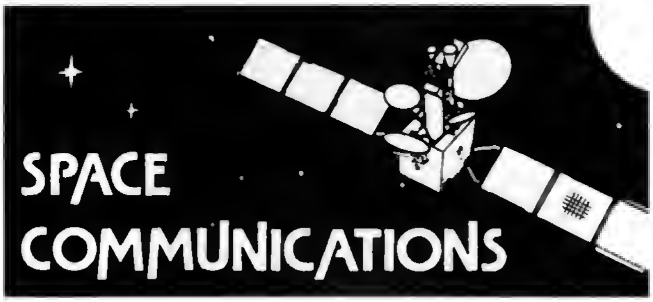
Using the RMS to move a plasma experiment around during the STS-3 mission in March 1982. *NASA*

for something, the brain must tell each joint simultaneously the direction, speed and distance. And it must be accurate. This is the way the arm computer in the Shuttle thinks. One control handle tells the computer which direction to move the arm. The computer then instantly goes through the complex calculations to find exactly how to move each joint. A second hand control is similarly used for rotations. Another way to control the arm is to use switches directly controlling each joint, one at a time. Yet another way is a totally automatic mode where preprogrammed sequences move the moves.

As Mr. Middleton explained these controls to me, some technicians came into the simulator to investigate a "failure injection". This means the computer had caused a joint to fail and they were trying to recradle the arm to its stowed position along the inside of the cargo bay.

If all of the joints fail on a mission, an astronaut may be able to move the arm back in himself by working outside in a space suite. I have tried this at NASA's underwater Space Shuttle facility, and found that it is impossible to move the arm unless it is right beside the Orbiter where there is something to hold. New procedures are being developed for such emergency stowage.

If the arm is stuck outside the orbiter, it can be automatically ejected — the astronauts have practised this in the simulator.



LEASAT CRADLE COMPLETED

British Aerospace has completed the reusable cradle designed to carry and launch Leasat military communications satellites from the cargo bay of the Shuttle. Designed by Hughes, the cradle was completed less than one year from the inception of the manufacturing programme.

Fabricated largely in aluminium alloy, the Leasat cradle is a C-shaped structure weighing 750 kg. It is 2 m long and measures 5 m across its open face. Five trunnions engage in the three longitudinal load-carrying channels provided for mounting equipment in the Shuttle's cargo bay. Spring force is used to eject the satellite.

Leasat is a military satellite being built by Hughes Aircraft for the US Department of Defense. The first of five is scheduled to be launched this year.

(Further details on Leasat can be found on pp.408 and 253 of 1983's Spaceflight *-Ed.)*

ARIANE OR SHUTTLE?

The decision on which launch vehicle to use for the final three Intelsat 6 communications (numbers F3 to F5) will be taken this month (March) by Intelsat's Board of Governers.

The 4000 kg satellites, each capable of handling 33,000 simultaneous telephone calls, will be launched either by Eruope's Ariane 4 or the US Shuttle. Intelsat have also been studying the possiblity of releasing two of the satellites during the *same* Shuttle mission.

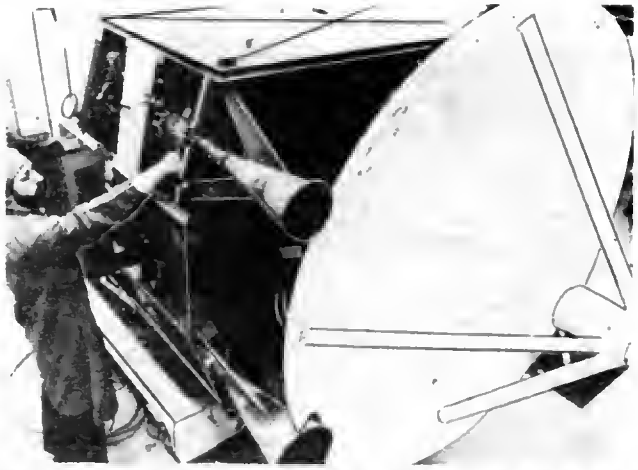
If Ariane is chosen, it will represent an important achievement for the vehicle in this competitive market.

NEW EARTH STATION

The ninth coast Earth station in the maritime satellite communications system has begun operations in Pleumeur Bodou, in the northwest corner of France, a site of importance in satellite history. The first intercontinental TV transmissions were received here from Telstar in June 1962. The maritime satellite system is operated by the International Maritime Satellite Organization (INMARSAT), while the coast Earth station is owned by the French national telecommunications agency. The station will provide telephone and telex services to ships and offshore drilling rigs in the Atlantic Ocean Region.

MARECS 1 CAPACITY INCREASE

At 00.01 GMT on 18 November 1983 a successful switching operation was peformed on ESA's operational maritime communications satellite Marecs 1, which pro-



The Marecs satellite (see story below) was built by British Aerospace.

vides the total of the Atlantic Ocean Region shore-to-ship and ship-to-shore satellite communications.

The switching operation, which increased the capacity from 30 simultaneous voice telephone channels to 46, was carried out in less than 10 minutes, thus avoiding the need to transfer communications to the spare satellite and back again.

Marecs 1 launched on 20 December 1981, has been the operational spacecraft providing Inmarsat's (International Maritime Satellite Organisation) maritime communications service in the Atlantic Ocean Region since 1 May 1982.

Marecs is now providing its full capacity for Inmarsat; a capacity in excess of the contractual requirement of 40 voice telephone channels.

ANTENNAE OF THE FUTURE

Research on the large antennae for the more "talkative" communications satellites envisaged for the 1990's and beyond has begun in a unique new facility at NASA's Lewis Research Center.

Involved is the precise measurement of the electric fields close to the antennae, the so-called near-field. From the measurements, far-field patterns can be determined such as would be produced on Earth by an antennae in space thousands of kilometres distant.

Large antennae testing is part of a broad Lewis effort to design, build, launch and conduct experiments with an advanced communications satellite operating in the higher 30/20 GHz range during this decade. Such a satellite will require a larger, more complex antennae than at present.

WALKING ON AIR

The success of the spacewalk – or Extra Vehicular Activity as NASA-speak would have it – on the last Shuttle mission underlined how far this aspect of manned space travel has gone. Ghostly images of suited astronauts floating across our TV screens have become a part of the Space Age as much as the spectacular blast-offs.

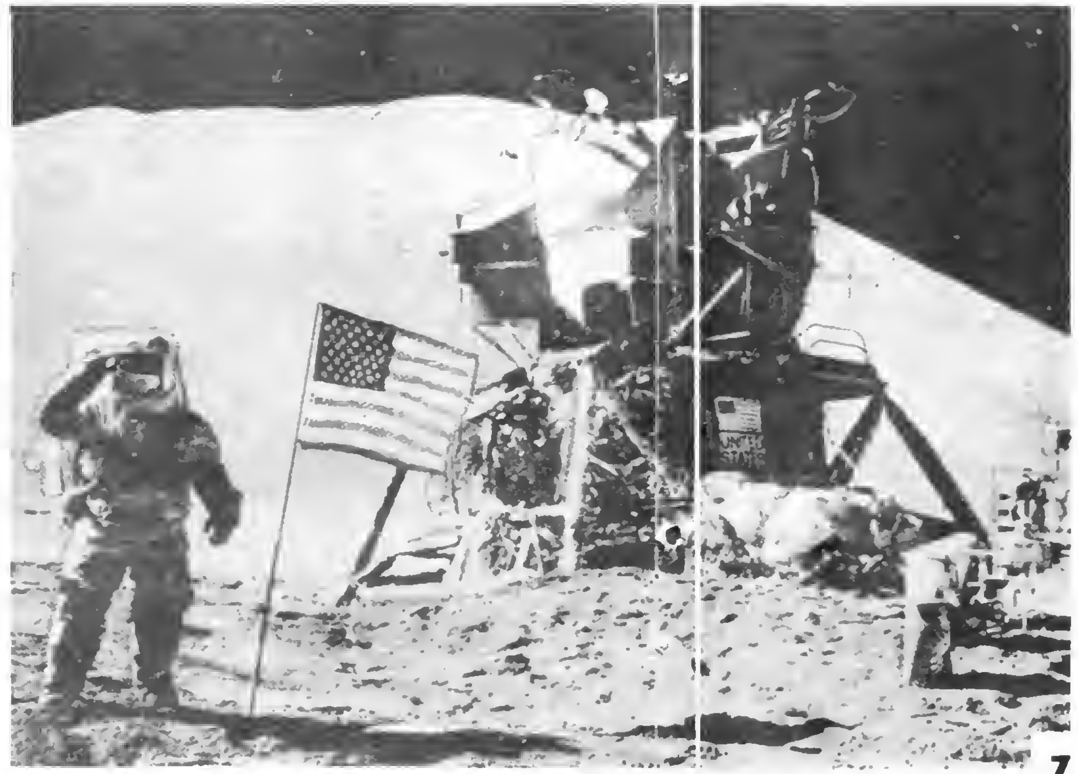
Yet the first walk in space was less than 20 years ago. Picture 1 shows a very grainy image of Alexie Leonov outside the Soviet Voskhod 2 ship on 18 March 1965. Number 2 shows the US response: Ed White in June 1965 from Gemini 4. The photographs were far better!

The Soviets left EVA alone for a while but Project Gemini saw astronauts working with Agena rocket stages. Picture 3 is of Dick Gordon (Gemini 11) returning from a docked Agena in 1966. With the advent of the Salyut space station, the Soviets had to develop an extensive EVA capability. We see few good shots from the Soviet space programme but picture 4, of Vladimir Kovalenok in July 1978 (Salyut 6), is excellent. Picture 5 illustrates underwater training techniques with a Salyut mockup.

The Shuttle EVA programme got underway on STS-6, with Story Musgrave (bands on legs) and Don Peterson demonstrating the basic capabilities. This August should see the first EVA by a woman.

Finally, picture 7 – how can we forget the Apollo Moonwalk? Twelve men roaming the surface of our nearest celestial neighbour a few days at a time between 1969 and 1971. Shown here is David Scott of Apollo 15 in the Hadley Rille area. As he said on that mission, "Man must explore and this is exploration at its greatest.

Soviet photographs: Novosti *US photographs: NASA*



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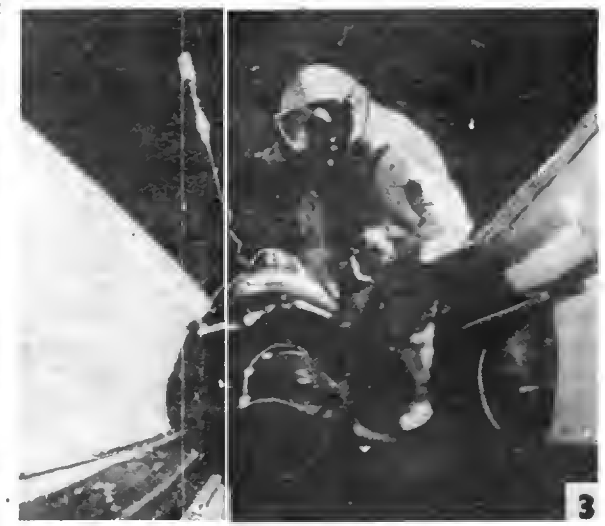

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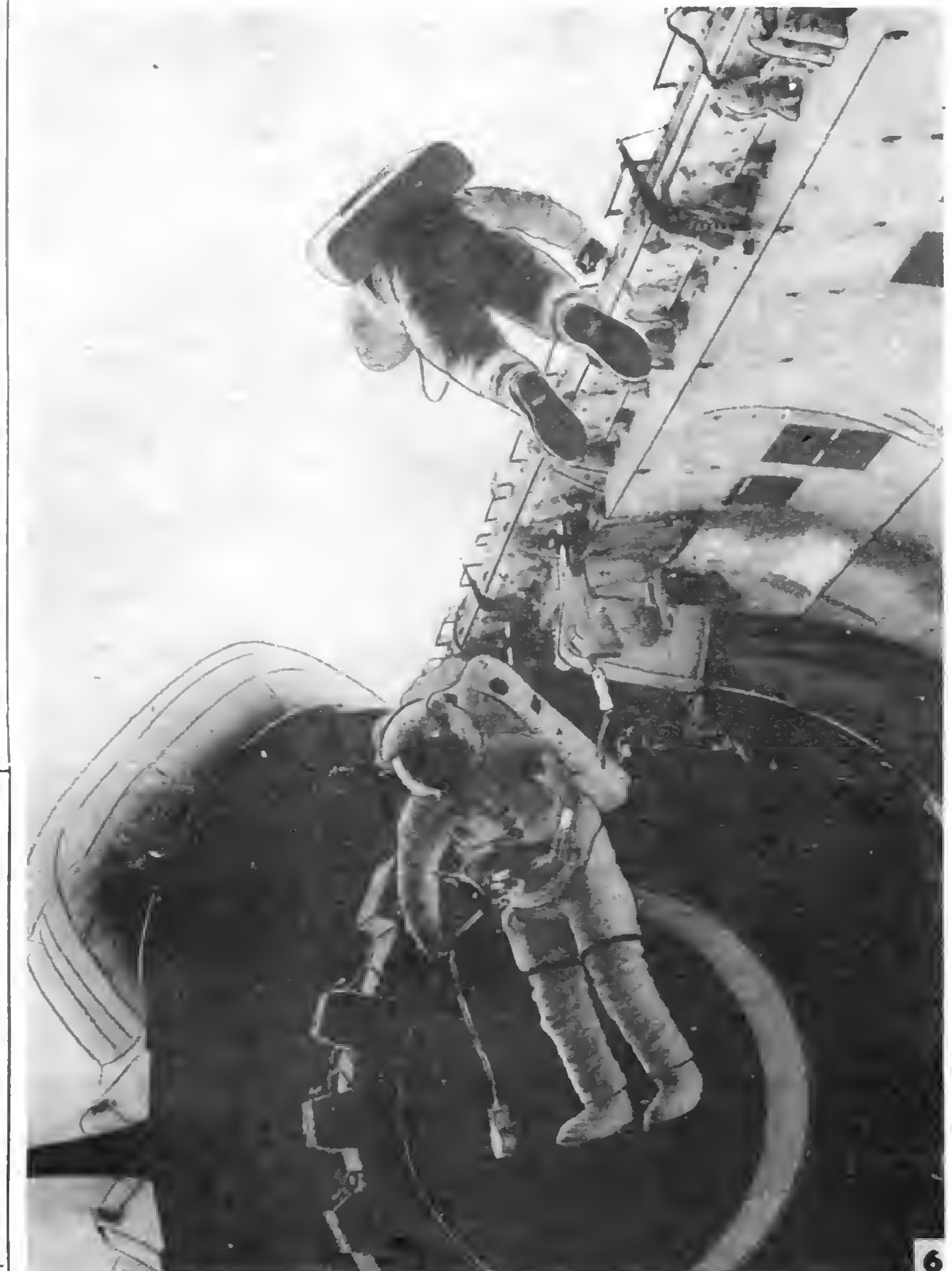

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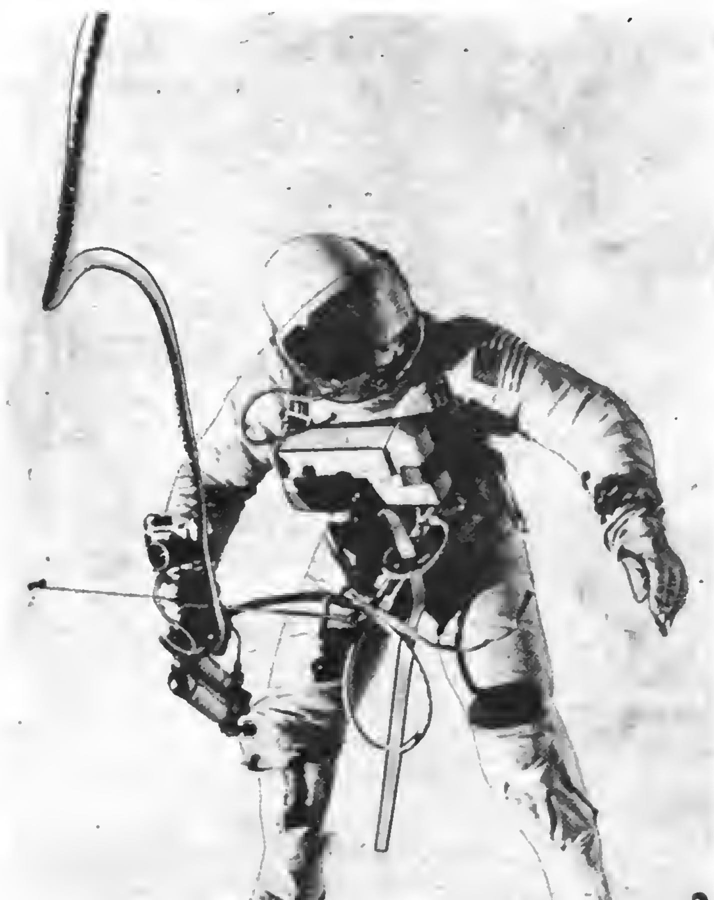

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SPACE SOUVENIRS

The Society produces a wide and varied range of items for sale, all of high quality. Why not buy a T-shirt or badge for yourself, or treat a friend? Remember, you'll not only support our work but also provide valuable advertising for the Society.

Binders

The ideal way of keeping your magazines in perfect condition. *Spaceflight* binders carry *BLUE* covers, those for *JBIS* are *GREEN*. Gold lettering on the spine identifies the magazine, volume number and year. Cost: £5 ($10 abroad) each. Note: *JBIS* binders fit post-1976 volumes.

T-SHIRTS

Our Society T-shirt has always been a popular item. Two styles are available: white with a large navy blue BIS logo on the chest, or navy blue with a pale blue logo.

The blue T-shirt in chest sizes 32-34, 34-36, & 42-44 inches. The white T-shirt is available in the two smaller sizes only. Cost is £3.50 in the UK or £4 ($8) abroad. Please be sure to specify the style, colour and size when ordering.

50th ANNIVERSARY TIES

We have always produced a high-quality navy blue tie that will grace any space buff's apparel. Now, to mark our 50th year, we are re-introducing the former blue tie showing a rocket against a star background.

For our 50th Anniversary year, the rockets will appear in GOLD to show, unmistakeably, that we have every reason to be proud of our achievements.

As these ties will be unique souvenirs only a limited number will be produced, so please place your order now to avoid disappointment. Next year, the ties will revert to the silver once more. The cost is £6 UK or £6.50 ($13) abroad per tie.

SPACE TANKARDS

In response to many demands, glass tankards of the type presented to the Speakers at the Society's Space '82 conference are being produced to mark **Space '84**, to be held in Brighton, 16–18 November 1984. Orders (UK only – sorry but we can't run the risk of damage in sending abroad) should be *sent direct* (not to the Society) to:

Western Glass International, Western Glass Works Ltd., Armstrong Rd., Daneshill East, Basingstoke, Hants RG24 0QE.

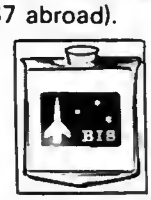
The cost is £10 (postage & packaging free). All profits will be donated to the Society so this is your chance to obtain a unique souvenir and to benefit the Society at the same time.

BADGES

A range of badges with the Society's motif is available.

Enamel lapel badges (1 in. diameter) and cloth blazer badges (3 in. diameter) cost just £1 ($2) each.

A special metal car badge adds that distinguished look to any vehicle for only £3 (£3.50 or $7 abroad).



Please note:

When ordering please specify colour, size, quantity, etc. as appropriate.

BACK VOLUMES

A small number of bound and unbound back volumes of *JBIS* and *Spaceflight* have come into the possession of the Society and are now being disposed of at nominal prices.

A list of those currently available can be obtained on request. Please order and remit promptly if you are interested as only single volumes are for sale in most cases and will be disposed of on a first-come first-served basis.

STS-8: *CHALLENGER'S* RETURN TO ORBIT

By John A. Pfannerstill

The sixth and seventh Shuttle missions in April and June 1983 proved Orbiter *Challenger* to be as good a flying machine as *Columbia*. By the eighth mission, the Shuttle flights had settled into a routine. This latest flight, though, had a new feature: both the launch and landing took place at night.

Introduction

Shuttle Mission 8 had the distinction of being the first flight in the Shuttle programme to undergo a major change in payload a few months before launch. It was originally slated to carry the small Indian Insat-1B communications/weather satellite and the second of three large Tracking and Data Relay Satellites (TDRS-B). However, problems with TDRS-1 after launch from STS-6 caused a revision. NASA management decided to delay the launch of TDRS-B until the problems could be studied and fixed. This decision left them with a difficult choice: either delay the entire mission and all its other flight-ready payloads until TDRS-B was cleared for flight, or fly it on schedule, but without TDRS. This would involve finding a suitable substitute payload.

The second alternative eventually won, leaving Mission 8 — only five months before its scheduled launch — with a sudden 19,500 kg of available capacity. The space was filled by the addition of the Remote Manipulator System and a large dumbbell-shaped structure called the Payload Flight Test Article, originally planned for Mission 11. Also carried to fill the gap were 260,000 commemorative postal covers which NASA and the US Postal Service had been wanting to fly for some time, but for which no space had been available.

There were those who criticised NASA's decision to fly STS-8 with substitute payloads. They claimed that the agency was scurrying around trying to find something — anything — to put aboard the Orbiter to get the flight off on schedule. Shuttle flights are too expensive, they argued, to be filled up with postal covers. The money would have been more wisely spent, they said, had STS-8 waited until TDRS-B was ready to fly.

Much of NASA's reasoning behind flying Mission 8 on-time was that one of the major objectives was to test the Orbiter's ability to communicate with the ground through TDRS-A. Despite the problems, the huge satellite was operational, and NASA wanted to try the system out on an actual Shuttle flight before the STS-9/Spacelab 1 mission flew in October 1983. The reason was that a good TDRS communication link was essential to the success of Spacelab 1. The complex laboratory was expected to gather so much data (much of it in real-time) that without TDRS-A's help, conventional ground tracking stations would be overloaded by the massive telemetry flow. There was also NASA's desire to fulfill its commitment to India for an on-time launch of Insat-1B.

The crew for STS-8 was chosen in April 1982. As was the case on Mission 7, the team consisted of one experienced astronaut and four "rookies." US Navy Captain Richard H. Truly was the commander and the lone space veteran (he had previously flown as the pilot on the 54 hr STS-2 mission in November 1981). He also flew in the approach and landing tests of *Enterprise* in 1977. Truly's pilot was Navy Commander Daniel C.

The spectacular night liftoff of STS-8 at 06:32 GMT on 30 August 1983.

Brandenstein. Flying as mission specialists were Navy Lt. Commander Dale A. Gardner (MS-1) and Air Force Lt. Col. Guion S. Bluford (MS-2), with the distinction of being the first black American to fly in space. A third mission specialist, Dr. William E. Thornton (MS-3), was added in December 1982 to the crew to study motion sickness. At the age of 54, Dr. Thornton would be the oldest person ever to fly in space.

The flight itself was at first scheduled to last six days, but was later expanded to seven to permit more TDRS testing. As on Missions 6 and 7, Orbiter OV-099, *Challenger*, was used, having already logged 11 d 2 h 47 m 52 s of flight time over these two missions.

First Night Launch and Landing

Operational considerations involving thermal and sensor constraints on the deployment of the Insat-1B satellite meant that launch had to take place at night shortly after 2:00 am local time at the Kennedy Space Center. This also meant the landing six days later would also have to be in darkness. This was because the STS-8 orbit precession rate did not provide a suitable daylight landing opportunity for the duration of the flight.

Initially apprehensive about the feasibility of landing the 100 tonne Orbiter in the dark, pilots Truly and Brandenstein went through extensive nighttime practice sessions using the Gulfstream-2 Shuttle Training Aircraft (STA), which left them confident that the operation would present no problems at all. Even though the landing was nominally planned for the Edwards Air Force Base in California, the two astronauts also practised night approaches at Northrup Strip in New Mexico, as well as the Kennedy Space Center, in case bad weather forced them to divert. In addition, nighttime Return to Launch

PAYLOADS AND EXPERIMENTS

As on most Shuttle flights, *Challenger* carried a varied payload for STS-8. Starting at the aft end of the payload bay:

Insat-1B Satellite

This multipurpose satellite, built by the Ford Aerospace Corporation for the government of India, was a combination communications and meteorological satellite designed to operate from geostationary orbit over 74°E. It was capable of handling telephone and TV links to many of India's remote areas as well as providing full-disc Earth images with a Very High Resolution Radiometer to aid in weather forecasting. Although using three-axis attitude stabilisation once on station, Insat was to be spinning as it left the Shuttle, thereby allowing the Payload Assist Module-D (PAM-D) to boost it into a transfer orbit.

Payload Flight Test Article (PFTA)

Occupying most of the middle of the payload bay, this 6.03 m long, 3,384 kg structure was designed to give the Remote Manipulator System arm a workout with the heaviest mass yet handled. Having a total of five RMS grapple fixtures located around its dumbbell-shaped frame, it was planned to use the arm to move the PFTA several times to obtain RMS engineering data in support of STS-13's planned deployment of the huge 9,000 kg Long Duration Exposure Facility in 1984. Since the PFTA was a passive structure with no electronics or attitude control there were no plans to release it. Once testing was completed, it would be brought back to Earth in the payload bay.

Development Flight Instrumentation (DFI) Pallet

While no DFI was carried on STS-8, the pallet used to mount it in *Columbia* in the test flights was flown aboard *Challenger* to carry two experiments and two boxes of postal covers. The experiments were:

The Evaluation of Oxygen Interaction with Materials: aimed at investigating how atomic oxygen reacts with various materials. Several samples of thermal tiles and insulation were mounted on the pallet as well as materials expected to be used on future space platforms to qualitatively examine any deterioration.

The High Capacity Heat Pipe Demonstration: the demonstration of a high-capacity heat pipe in space which may be used as a heat-dissipating system on future spacecraft.

US Postal Service Payload

In a cooperative effort with NASA, the US Postal Service flew 260,000 commemorative postal covers. Some were packed into two large storage boxes bolted to the DFI pallet and the remainder were put into eight Getaway Special Canisters. After the flight, the covers were offered for sale as souvenirs of the mission. NASA and the USPS split the profits from the sale evenly, each netting about $3 million.

Guion Bluford undergoing a medical test in the middeck area.

Getaway Special (GAS) Payloads

The mission carried four GAS canisters, bringing to 16 the total number flown aboard Shuttles to that time. This time they were:

GAS-G346: The Cosmic Ray Upset Experiment (CRUX) investigated the effects of cosmic rays on memory-type integrated circuits. (NASA's Goddard Space Flight Center.)

GAS-G347: The Ultraviolet Emulsion Experiment was similar to the GAS-G345 payload flown on STS-7, and was designed to assess the effects of charged particles in space on six different types of UV-sensitive photographic films. (NASA's Goddard Space Flight Center.)

GAS-G348: The Contamination Monitor Package was a third Goddard-sponsored payload and had the distinction of being the first GAS experiment to be mounted atop the canister lid. Similar to the unit flown as part of the OSS-1 payload on STS-3, the experiment was desinged to monitor atomic oxygen flux.

GAS-G457: Artificial Snow Crystal Experiment was a re-flight of the unsuccessful GAS-G005 flown on STS-6. Designed to investigate snow crystal formation in zero-G, it carried improved equipment to correct the problems encountered on its earlier flight. It was sponsored by the Japanese newspaper *Asahi Shimbun*.

Remote Manipulator System (RMS)

Rounding out the equipment carried in the payload bay was the RMS. On this flight, the 15.24 m arm was to be used mainly in conjunction with the PFTA. As on previous missions, the arm was mounted along the port side of the payload bay. The arm hardware itself was the same as that flown on Missions 2, 3, 4 and 7.

In addition to these payloads carried in the bay, *Challenger* also carried several experiments inside the pressurised crew module. They were:

Continuous Flow Electrophoresis System (CFES)

This was making its fourth Shuttle flight, having flown aboard *Columbia* on STS-4 and *Challenger* on STS-6 & 7. Aimed at the commercial marketing of space-processed medicines, the CFES uses an electrical field to separate cells depending on their surface electrical charge. Results from previous missions showed that this separation process permits 700 times more material to be processed in zero-g than in a conventional Earth environment. On its three previous flight, the CFES was used to separate proteins and various other inert samples. On STS-8, however, an attempt was made to separate living cells for the first time. Among the six samples processed were live kidney and pancreas cells. Scientists hoped to use this processed material in the production of improved medicines for the treatment of diabetes.

Shuttle Student Involvement Program Experiments

Two investigations proposed by students were flown:

Biofeedback Mediated Behavioral Training: the determination of whether or not bio-feedback training learned on Earth can be successfully transferred to a zero-g environment.

Animal Enclosure Module (AEM): a sophisticated animal cage, the AEM was flown with six live rats in order to check its operation before use on a future Shuttle student experiment.

The crew for STS-8. From left: Daniel Brandenstein (Pilot), Dale Gardner (Mission Specialist), Dick Truly (Commander), Bill Thornton (MS) and Guion Bluford (MS).

Site (RTLS) abort profiles were extensively practised at Kennedy until Truly and Brandenstein felt comfortable.

According to Lt. Gen. James Abrahamson, NASA's Shuttle chief, nighttime launchings and landings might eventually become more desirable than daytime ones. He said studies indicated that in Florida at least, the weather tended to be better at night with calmer winds and clearer skies. But, for the time being, all Shuttle liftoffs and landings were baselined for daytime unless there was no way of avoiding night work.

Launch Day: 30 August 1983

The liftoff promised to be spectacular. The planned launch time of 06:15 GMT (all times are GMT) on 30 August was some four hours before sunrise at KSC, thereby making STS-8 the first Shuttle flight ever to take off at night.

Forecasters predicted some of the best weather yet for a launch, with calm winds, warm temperatures and clear skies. This was good news for residents of the south-eastern US and Carribbean islanders. The expectations were that, given good clear skies, the brilliant glow from the Shuttle's two Solid Rocket Boosters (SRBs) would be visible 700 km away.

However, conditions rapidly turned sour. By the time the astronauts left their quarters for the drive to the pad, the entire area was enveloped in a driving rainstorm.

Throughout the final hours of the countdown with the five-man crew aboard the Orbiter, lightning flashed around the pad, thunder rumbled and rain showers sent spectators and newsmen heading for cover. KSC's Public Affairs commentator Mark Hess at one point acknowleged that the situation "did not look promising" and that a scrub because of the weather conditions was becoming more and more likely.

Launch Director Al O'Hara decided to extend what normally would have been a 10 minute built-in hold at the T−9 minutes mark to see if the weather would improve. Surprisingly, it did. STS-7 astronaut Robert Crippen, flying in the STA trying simulated RTLS abort approaches, found that the rain had stopped, there was no lightning in the area, and visibility was good. As a result, the countdown was picked up at 06:23, and from there proceeded smoothly to zero. At 06:32:00, only 17 minutes late, *Challenger* slipped its moorings for the third time and headed skyward.

The dazzling light from the twin SRB plumes lit up the entire area in a spectacle that made the only other US manned night launch (Apollo 17 in December 1972) look pale in comparison. The sight did not last long, however, for *Challenger* climbed rapidly out of view, leaving behind a floodlit launch pad shrouded in smoke and steam with a large brush fire burning nearby.

From the crew's point of view, the launch was also spectacular. "It was pretty surprising," mission specialist Dale Gardner recalled later, "I looked back at the ignition of the SSMEs [main engines] and SRBs and nearly blinded myself. It looked like we were just totally engulfed in a ball of flame... the flame appeared to be all around us. Later, at six or seven minutes, I again looked back and was really surprised. Just the main engines themselves were making a much brighter orange flame that I ever expected, and it was pulsating almost as if an engine was running unstable. In fact, I asked Dan (Brandenstein) if all the engines were okay."

Despite Gardner's concern, the engines were in excellent shape and they performed perfectly. By the time they shut down at 8 m 42 s mission elapsed time (MET), *Challenger* was right on target. External Tank separation took place without incident and both of the standard Orbital Maneuvering System (OMS) burns were accomplished successfully, placing the Orbiter into a 296 km circular orbit inclined at 28.5 degrees to the equator.

After opening the payload bay doors, the crew transmitted colour TV pictures of the bay's contents. Conspicuous in the broadcast was a huge American flag painted on one side of the PFTA, which occupied most of the bay.

Scientific research began almost immediately. Within 3.5 hours of liftoff, mission specialist Guy Bluford had the CFES powered up and ready for work. Insat deployment was scheduled for the next day so that Bluford could devote his full attention to the CFES, which for the first

Bill Thornton (right) and Dale Gardner conduct audiometry tests in the Orbiter middeck as part of the studies into space sickness.

time would involve the processing of living cells. This was the reason for all the urgency. It was important that the cells be processed while they were still alive.

While Bluford was involved in this activity, Dr. Thornton unstowed all of his gear and began setting up "Dr. Bill's Clinic" in *Challenger*'s middeck. In other activities, Truly and Brandenstein oriented *Challenger* such that its nose was pointing toward the Earth and its starboard side into the direction of flight. The purpose of this was to photograph the Orbiter's "glow phenomenon" first observed by astronauts Lousma and Fullerton on STS-3, and to provide a maximum amount of exposure to the Oxygen Interaction experiment in the payload bay.

The crew also conducted the first communication tests using TDRS-1. No TV was attempted, but voice transmissions and spacecraft telemetry data came through loud and clear in Mission Control Center-Houston (MCC-H), proving at last that the TDRS system did work.

Mission Day 2: 31 August 1983

The astronauts' second day in space began with a rousing rendition of the Georgia Tech fight song in honour of commander Dick Truly, a 1959 graduate of the school. The day was to be highlighted by the deployment of the only commercial satellite payload, Insat-1B.

Deployment preparations began at about 06:00 on 31 August, almost two hours before ejection over the central Pacific at the start of *Challenger's* 18th orbit. The Insat deployment procedures were similar to those of Missions 5 and 7, whose crews launched a total of four HS-376 type satellites. Because of Insat's different design and operational requirements the present crew had slightly more extensive checking to perform before release.

By 07:29, everything was ready and the crew started the mechanical sequence on the PAM and the final countdown. This led up to the deployment of the satellite at 07:49, precisely on time.

Spinning at 40 rpm the glittering blue and gold Insat separated at 0.76 m/s. The deployment was extremely accurate, within 1500 m of the target point and 0.09 degrees of the desired pointing angle.

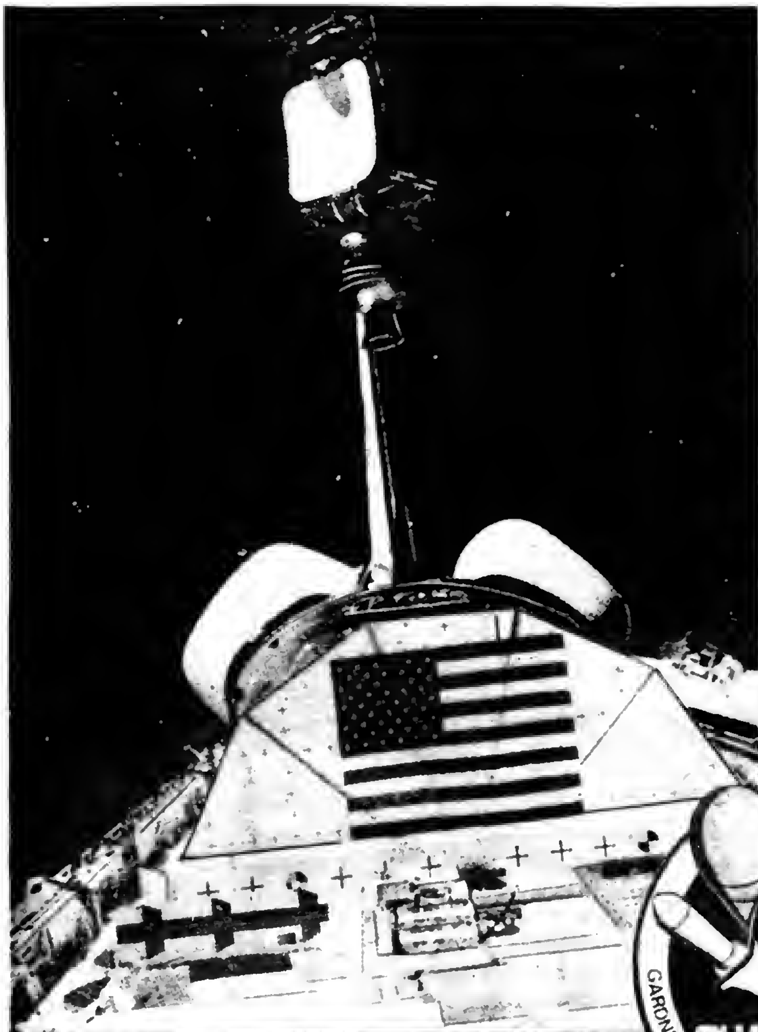
"We're happy to let you know," Bluford said, "that Insat was deployed on time with no anomalies and the satellite looked good."

Just as planned, exactly 45 minutes after the satellite left the payload bay, the solid propellant PAM motor fired to push Insat into a 38,173 by 296 km geostationary transfer orbit. The satellite's own liquid propellant motor would then be used over the next few days to stabilise the orbit at geostationary altitude over 74°E longitude. The Shuttle had proved once again that it was an accurate and reliable satellite launching platform.

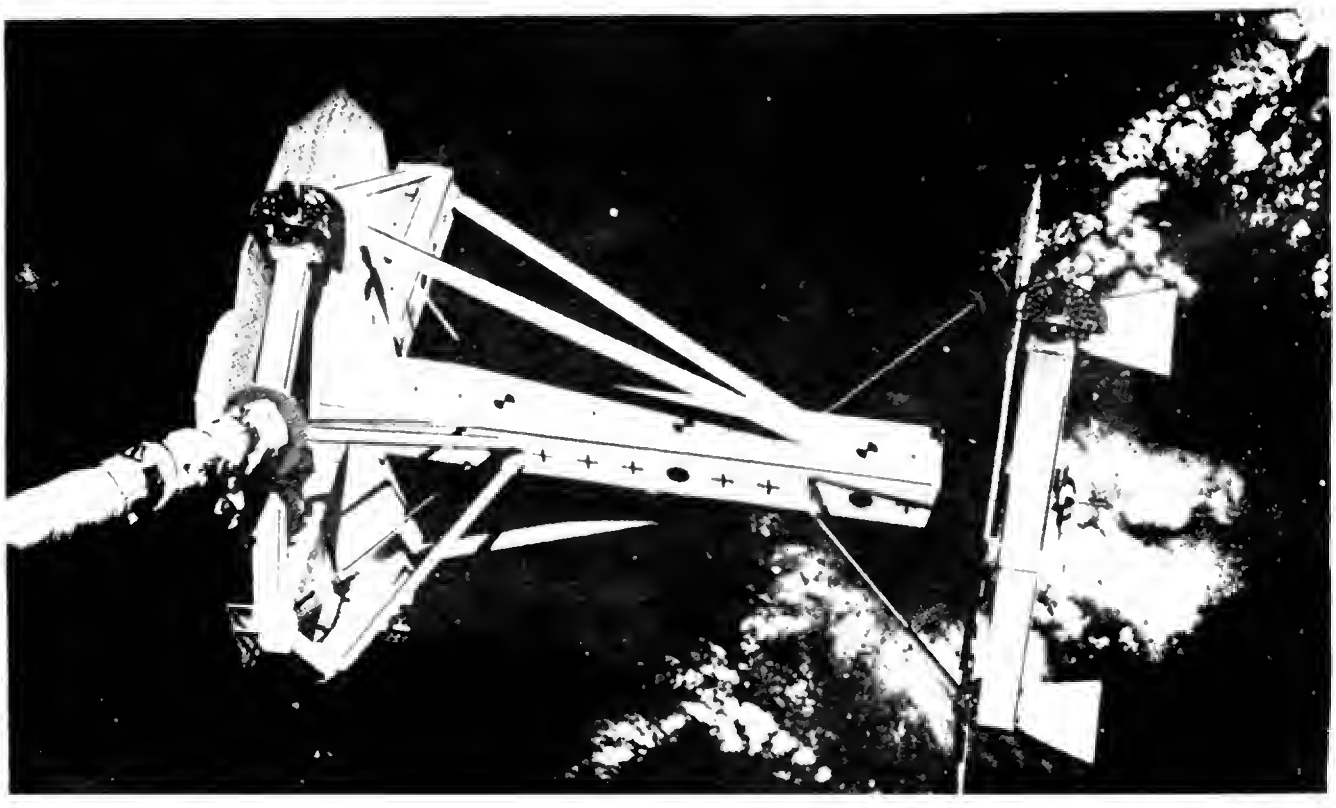
After the deployment, the astronauts gathered in the middeck before the TV camera to receive a telephone call from President Reagan. He congratulated the crew on their accomplishments thus far, singling out for special praise Bluford as America's first black astronaut, and Dr. Thornton as the oldest person ever to fly in space. As Reagan too was the oldest US President ever to serve, he said that Thornton had "a specially warm place" in his heart, and added, "It makes me think that maybe some day I might be able to go along."

The day was rounded out by more tests of the TDRS, which included the first TV transmissions through the relay satellite, and six hours of work with the CFES in which Gardner processed living kidney and pituitary gland cells.

The astronauts also spent some time in Earth observations. Their night launch allowed them many excellent daylight passes over southern hemisphere targets which had been inaccessible to previous Shuttle crews. During their first night in orbit, Truly and Brandenstein spotted two active volcanoes in the vicinity of New Guinea. The



Above: The deployment of Insat-1B from *Challenger's* payload bay during the second day. The large US flag is painted on the PFTA. *Below:* With the Earth as a backdrop, the huge Payload Flight Test Article is suspended from the end of *Challenger's* Remote Manipulator arm. *Right;* Dan Brandenstein at the rear of the cockpit.



Mission 8 crew had on board over 2500 frames of colour stills film. This was more than had been carried by any US space mission since the Skylab flights of 1973/74, and much of it was used for Earth terrain photography.

Mission Day 3: 1 September 1983

Day 3 was taken up mainly by tests on the RMS arm using the PFTA. The flight plan had been purposely kept relatively light in order to allow for a backup Insat deployment opportunity had one been needed. It wasn't and so the astronauts had a more relaxed day.

But before the day even got started, a problem came up. During the night, a failure at the White Sands, New Mexico TDRS control centre knocked out the Shuttle-TDRS-MCC telemetry link for some three hours. Truly had to be awakened by MCC–H to re-position some switches which would allow Orbiter telemetry to be routed through the traditional ground stations rather than TDRS for the remainder of the sleep period. It was a problem that would continue to crop up throughout the rest of the mission. TDRS itself was functioning fine — in fact, TV and voice communications were noticeably better when the relay satellite was used — the problem was with the complex ground-based computer system needed to support TDRS operations. All of the bugs were apparently not yet out of the new system.

Testing of the RMS, which was the main order of the day, began at about 09:00 on 1 September when Gardner unberthed the PFTA. For nearly seven hours, he manoeuvred the huge, 3384 kg dumb-bell shaped mass around the Orbiter, stopping it at various precalculated points so that Truly and Brandenstein could fire the RCS jets to see what effect the acceleration would have on the loaded arm. Each time, the PFTA and the arm could be seen to move slightly, but the motion was not great, requiring only a few seconds to damp out. Gardner also tried various RMS control modes and berthing techniques before concluding his tests for the day by putting the mass back in the bay.

Meanwhile, Dr. Thornton continued his motion sickness studies. His work kept him so busy that he was hardly ever heard on the air-to-ground communications circuit. In fact, the other astronauts said that he usually did not even bother to put on a headset. His equipment took up a good portion of the middeck and, as Dr. Thagard had done on STS–7, he used *Challenger*'s cylindrical EVA airlock as an office.

The other astronauts, particularly Truly, spent some of the day giving very detailed verbal descriptions of geological features. During one pass over Australia the Mission 8 commander made the following report:

"In the area of about 26 degress South and about 110 degrees East, there is a huge area of extremely large and complex drainage rivers out in the desert. We happened to glance down and see that it makes a perfect circle. It almost looks like a huge old impact crater where the drainage rivers had formed a periphery of it."

Later studies showed that the structure Tuly observed was most likely not an impact crater at all, but rather a large ancient river basin. Still, his description sent geologists at the Johnson Space Center scurrying for maps and Landsat images of the area to correlate with his report, since they knew of no impact craters in that particular area.

Mission Day 4: 2 September 1983

One of the crew's first activities on the fourth day was to lower *Challenger's* orbit. Truly and Brandenstein fired the OMS engines twice to establish a 222 km circular orbit. The lower orbit was desired to support the O

Interaction experiment by providing a higher density of oxygen molecules to impact on the various test materials in the payload bay.

The lower orbit also allowed Truly to get a closer look at the circular structure he had observed in Australia on the previous day. In addition, the crewmen sighted tropical storm Ellen, which was situated between Guam and New Guinea, and they observed more erupting volcanoes in the South Pacific. Sometimes, the astronauts just sat back during a meal period and enjoyed the beautiful view below with all the cockpit lights turned off.

The main work of the day was more testing of the TDRS and additional work with the RMS and the PFTA. Once again, Gardner used the arm to hoist the structure out of the bay for about five hours of tests which were very similar to those performed the day before.

The TDRS testing was once again broken up by intermittent ground-related problems. The trouble seemed to lie most often in the initial establishment of the link. Usually, once the TDRS-Orbiter contact was made, it could be maintained without difficulty for the remainder of the pass, providing superb quality TV voice and data.

Mission Day 5: 3 September 1983

The main operational activity of Day 5 was the third and final phase of tests with the RMS and the PFTA. Gardner used the end grapple fixture on the PFTA to perform a series of direct-drive berthing and unberthing tests, all of which went well. In an additional test Gardner hooked the unloaded arm over *Challenger's* port side and around underneath the Orbiter. Then, using the TV camera mounted on the end effector, he was able to inspect the condition of *Challenger's* belly thermal tiles. This was a first, proving that an emergency non-EVA inspection was possible.

The crew also made more TDRS tests, one involving an evaluation of how well the Orbiter antennae could track the satellite in the midst of a continuous pitch manoeuvre.

During one TDRS contact, beginning at about 07:40 on 3 September, the crew gathered in the middeck for a 24 minute TV news conference with a pool of six reporters who were permitted to talk directly with the astronauts. The newsmen were from the three major American TV networks, one newspaper, and the AP and UPI wire services.

Many of the questions were directed at Dr. Thornton and his inquiry into space sickness. He said that "the Orbiter in space is the place to study the problem and I think I learned more in the first hour and a half than I have in all the previous years that I've put in on it. It's a transient thing and not the dreaded monster it's made out to be. I'm convinced the problem is very solvable."

When asked specifically if any members of the STS–8 crew had gotten sick, Thornton evasively replied, "We have seen a variety, a range of symptoms and adaptation, and that's what I came to study." His answer was in keeping with NASA's new policy of not disclosing minor in-flight illnesses, but it did seem to imply that at least one of the astronauts had been sick.

Other questions were directed at Bluford concerning his thoughts on being the first black American in space and at Truly and Brandenstein on the upcoming night landing.

The conference ended with the crew being asked to vote on whether or not to stay in space longer than the planned mission duration, or to come down on time. It

Facing page: **Approaching the end of its flight, *Challenger* descends**

was too short for flying we would be drilled in safety, meteorology, survival and navigation. The bright stars, with their wonderful Arabic names, became familiar friends. As a lifelong yachtsman I still enjoy navigating by them in races. At last we finished basic flight training and were introduced to combat tactics, carrier landings and the grand old PBY Catalina flying boats. Cursed and perhaps secretly loved by their serious wartime users, these old monsters were just giant toys for us. At their hypnotically slow cruising speeds we spent hours musing on the patterns of sunlight upon the sea. Perhaps then was implanted deep knowledge of the magic of a huge, slow-moving wing: magic to be realised 30 years later in the wings that won the Kremer Prizes (see later).

With training finished and a Naval Reserve assignment to an air station in Southern California, I returned to Caltech in 1947 for graduate work in Aeronautics. Henry Nagamatsu, my thesis advisor, asked me if I would like to do some calculations on sounding-rocket performance for Professor H. J. Stewart. The other choice was a complicated problem of dynamic gust-load alleviation for transport aircraft, proposed by Clark Millikan of Caltech and Arthur Raymond of the Douglas Aircraft Company. Both of them were old friends of my parents and had shared the depression-era desert camps.

I selected the rocket thesis because it looked easier and also to avoid disappointing those beloved and admired friends, should I turn out to be less than brilliant. Thus began the path that led to JPL.

As a typical graduated student I earned a little money by operating the Caltech wind tunnels, and in the summer I worked as a draftsman at Douglas, portraying the least important parts of the C-124 Globemaster, a large and portly cargo plane. (Again the very efficient, big, slow-flying wing.) In due course I received my Aeronautics degree and, almost without considering any other possibilities, joined JPL.

That winter at Mammoth Mountain in the Sierras, I had observed a certain young lady skiing. We later met at a party and that was that. Lin (her real name is Caroline) is a dancer and lover of mountains, especially those around her family's little cabins high in the Wyoming Rockies. Our five children, now all grown and flourishing, learned some of their most important lessons there.

The Army Missile Era

My first task at JPL was to design a small, fast rocket for outdoor research in supersonic aerodynamics. It developed into the Loki missile, an unguided antiaircraft rocket. We launched thousands of them at White Sands, and various versions of Loki have continued in use for decades as upper-atmosphere sounding rockets.

We had, of course, many adventures. Early on, the rockets were breaking up in flight. I developed a complicated aero-thermo-elastic theory to explain the phenomenon. H. J. Stewart examined the calculations and innocently asked me if I knew how fast the rocket was spinning, when it was going at Mach 5. That was easy to calculate; the tail fins were canted one-half degree. At once it was obvious that the long, slender rocket had exceeded its classic critical speed just as an unsupported, spinning shaft! So much for my fine theory. We stiffened the structure a bit and bent the fin tips so as to slow the spin, and the next rocket flew perfectly. Later we got into instrumenting spin rate as a means of investigating dispersion about the

Loki. The solid-propellant booster burns for about 1½ seconds, accelerating the unpowered dart to about 1.5 km/s; the dart then coasted up into the stratosphere.

night, electric lights. One rocket lit off with a roar and our spinsonde telemetry expert exclaimed, "Wow! really strong signal this time!" Just then our boss appeared at the door of the telemetry trailer, with the spinsonde transmitter in his hand, and said, "Would this be what you are listening to?" The rocket had stuck in the launcher and the transmitter had landed in the sand a few yards away.

Loki taught us many lessons, and as a desert lover and longtime admirer of Mexican civilization I found White Sands, and the traditional soirées across the border in Juarez, much to my liking.

While we were working on Loki another team at JPL was converting the Corporal research rocket into a rather clumsy Army missile. That was followed by Sergeant, which gave a whole generation of JPL engineers its first experience with a big, modern, complex system designed from the beginning for one purpose. The heritage of Sergeant can still be traced in JPL's philosophy for balancing competing design characteristics, in our organization and test methods, and in our electronics packaging technique. Three of us were credited with inventing a new, simple and precise combination of controls for Sergeant. The project also included building and testing scale models of the missile's big solid rocket engine. These became useful in their own right, being applied to various missions culminating in launch of the first Explorer satellites.

The Sergeant was highly successful for its time. The system was transferred from JPL to industry, produced and deployed by the Army. As with other nuclear weapons, Sergeant's success is perhaps best measured

Into Deep Space

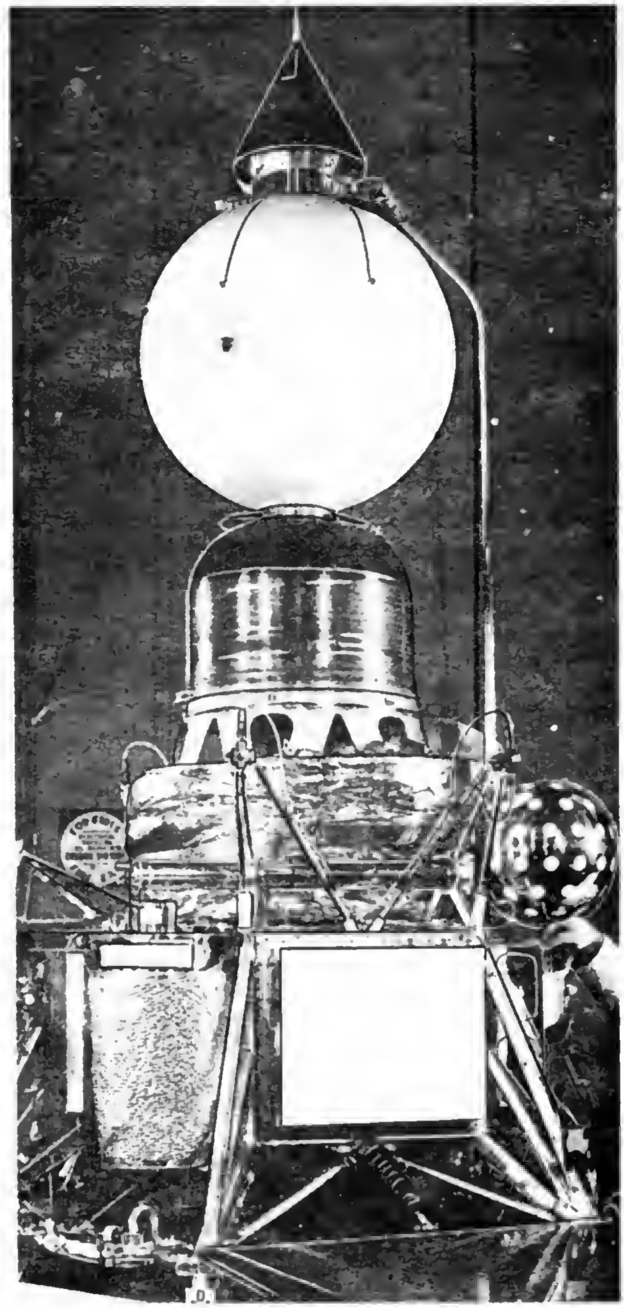
On 4 October 1957, JPL's heroic age began. My boss ran out of his office shouting, "It's up!" "What's up?" "The satellite!" Though disappointed at being beaten by the Soviets, we were elated by Sputnik. At once we knew that our most cherished dreams would now become reality. As has been told in several histories [1, 2], the Army Ballistic Missile Agency and JPL had already prepared and suborbitally tested a satellite launch vehicle. On 31 January 1958 [*1 February in GMT – Ed.*], Explorer I went into orbit and our new era began. More satellites followed, but I was only slightly involved with them. Through 1958 and 1959 I was a member of various study teams trying to define the next step. Clearly it would be a flight to the Moon, but which combination of rockets should we use? Configurations came and went in a dizzying sequence. The engineering went on in a highly political atmosphere as the Army and Air Force quarrelled, NASA struggled to be born, and the country slowly rose to meet the Soviet challenge.

On 2 January 1959, a clear moonlit night, Lin and I sat talking quietly, alone on the cool sand of Redondo Beach. I was leaving on the midnight 'plane to Washington, known to all as the "redeye." Somewhere above us the Soviet probe *Mechta*, launched that day, was rushing away from Earth -- the first human artifact to achieve what the Russians call the second cosmic speed. We wondered if *Mechta* (dream) was named for Kepler's *Somnium*. To me, this was the real watershed. Sputnik and Explorer I were of course important – but they, and all satellites, are still parts of Earth, inexorably bound by gravity to our planet. *Mechta*, in contrast, had escaped; now the Solar System lay open before us.

The stern chase continued but America was gaining. On 3 March 1959, Pioneer IV escaped into interplanetary space. On 30 April JPL published its manifesto [3] for the dawning deep-space age. We committed ourselves to exploring the Moon and planets. Two programme offices, one lunar and one planetary, were formed. From the beginning it was intended that the lunar projects would, as soon as feasible, be put out as system contracts to industry, while the planetary projects would be done in-house at JPL. My own role in the events that followed is described in Refs. 4 and 5. In 1960 I was appointed to head Project Ranger, the first American attempt to place operating instruments on the Moon.

We had to learn quickly how to do many new things. To build reliable spacecraft as fast as possible, we adopted the concept of a common "bus" incorporating attitude and manoeuvre control, solar power and telecommunications, upon which various mission payloads could be mounted. We insisted on continuous operation (turning electronic equipment on and off is bad for it) and on continuous contact with the spacecraft. This required deep-space tracking stations all around the world. The building of the Deep Space Network, with stations in California, Australia, Africa, and Spain [6] was one remarkable achievement of those times.

Because we always viewed it as a precursor to planetary missions, Ranger was more complicated than would have been needed just for its lunar objectives. Though it later proved very burdensome to JPL and to me personally, I still believe that this was the right choice. Some of my other decisions regarding Ranger were not so defensible. Historians [4, 5], as well as official investigators [7], have remarked on my undue haste. Hurrying undoubtedly contributed to the early



The Ranger 3 craft. The white sphere at the top is the lunar-landing capsule, with an omnidirectional antenna perched on top during launch. Below the sphere is its retromotor, used to slow the sphere for a safe landing on the Moon.

our own tight schedules while other projects slipped, we came to be using the USAF Atlas-Agena B launch vehicle earlier in its own sequence of development, so we experienced the early failures of vehicle stages that later became very reliable. Also, it is clear in retrospect that I should have paid more attention to our own problems within JPL; we should have taken more time and care in developing and testing a spacecraft whose objectives were so very ambitious for its day.

We did have a great sense of urgency. There were three reasons for my haste. One I regard as entirely proper, the second is debatable, and the third remains controversial. First, viewing Ranger as a precursor to planetary missions whose launch dates are set by celestial mechanics, we *had* to learn how to carry out a complex development leading to an immovable launch window. Second, I knew full well the pernicious cost effects of slipping milestone schedules. When a big project is up and running, a great taxi-meter is going

costly. Third, we wanted to beat the Soviets to the Moon. In 1959 Luna 2 had impacted on it and Luna 3 had photographed its far side. The obvious next steps were to orbit the Moon and to land instruments on its surface. When Ranger was being planned there was still a chance that the USAF's Atlas-Able lunar orbiters [8] might succeed, so Ranger was aimed at a landing.

In October 1960 and February 1961 the Soviets attempted launches to Mars and Venus [9], one of which sent Venera 1 on its way. Even though the spacecraft failed *enroute* to Venus, this mission was a powerful spur to our efforts. Pictures of Venera 1 showed oriented solar panels and a high-gain antenna, and its announced mass enabled us to calculate the large payloads that the Soviets could then send to the Moon. Later in the spring of 1961, as we were preparing Ranger 1 for launch, Yuri Gagarin went into orbit and President Kennedy committed the United States to Apollo. So we kept whipping Ranger along. It may not have been prudent, but it was in keeping with the times.

Historians have also remarked on some disputes that I, as Ranger Project Manager, had with scientists. However, I was never opposed to *lunar* science on Ranger, nor did I object to the magnetospheric experiments on our first two simplified test shots, Rangers 1 and 2, which were not aimed at the Moon. Indeed I insisted [10] that every flight must carry scientific instruments, because (a) we could not tell in advance which flight or flights might succeed, and (b) engineering development of the instruments was as important as that of any other subsystem. I did do battle with scientists who wanted to load lunar Rangers with non-lunar experiments and also, on occasion, with scientists who were not ready and wanted the project to wait for them. Our lunar experimenters never gave us this problem.

Ranger 1 failed to escape Earth orbit because a switch overheated in the engine compartment of the Agena.

Ranger 2 failed to escape Earth orbit because, due to a faulty design concept in the blockhouse monitoring instruments, the Agena was launched with its gyros inoperative.

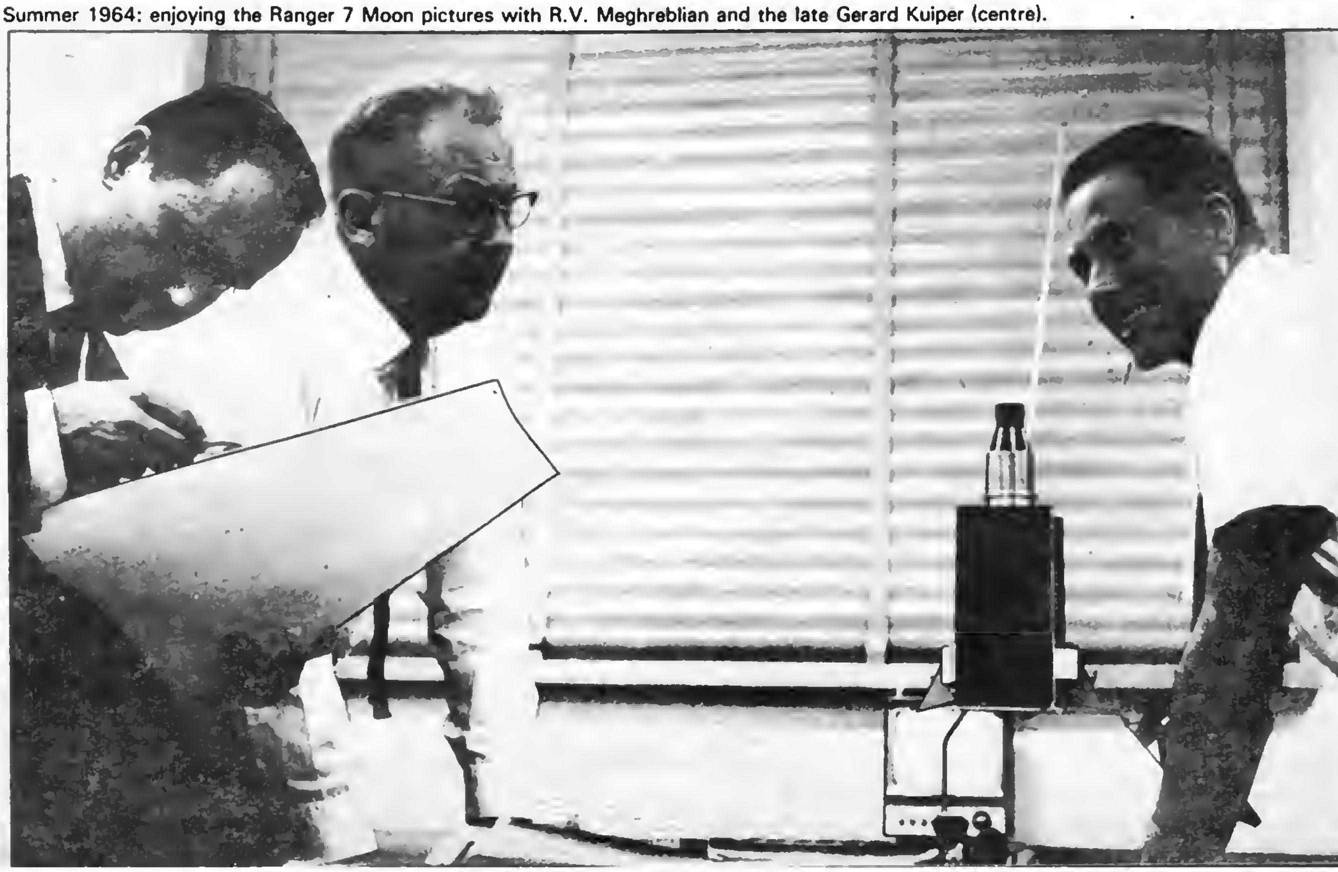
Ranger 3, our first lunar Ranger, missed the Moon because of a guidance failure in the Atlas. The spacecraft operated well until the lunar flyby, when its central computer and sequencer inexplicably failed.

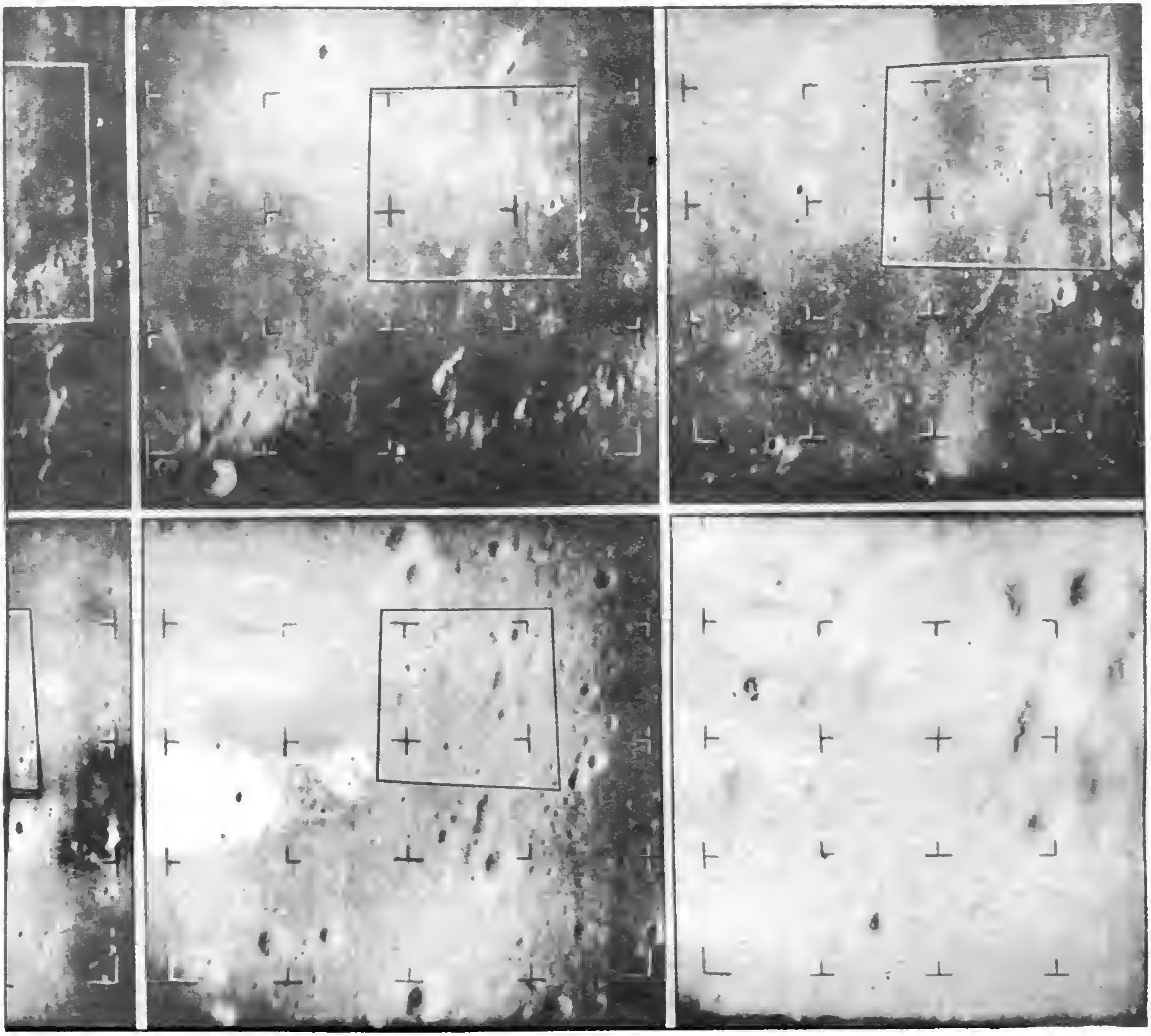
Ranger 4 was our first perfect Atlas-Agena launch, but when the spacecraft separated from the Agena a floating conductive particle shorted out two critical pins in the separation connector. The dead spacecraft went on to lunar impact, tracked only by the signal of the small transmitter in the lunar capsule payload.

After Ranger 4, which hit the Moon on 26 April 1962, we stood down to allow the JPL planetary team to launch Mariners 1 and 2. (In Ref. 11 Jack James, the Mariner Project Manager, tells the remarkable story of Mariner 2's flight to Venus.) Lin and I travelled in Denmark, France and Britain while Ranger 5, our last hope for delivering an operating instrument to the Moon, was carefully prepared for launch. Should we have stayed home? Of course I shall never know whether or not it would have made any difference. The glorious news of Mariner 2's successful launch came to us in a cable from Jack James. I opened it as we rode up in a lift at Grosvenor House in London. My whoop must have startled the staff, but they exclaimed "good show!" and immediately champagne and flowers arrived in our room. Such were those days.

On 18 October 1962, Ranger 5 lifted off. Atlas-Agena guidance had some errors, but the trajectory was correctable to the Moon. The spacecraft stabilized itself and acquired solar lock. Then a 10-32 terminal feed-through screw in the power switching and logic unit, warmed by the current flowing through it, leng-

Summer 1964: enjoying the Ranger 7 Moon pictures with R.V. Meghreblian and the late Gerard Kuiper (centre).





Success at last! Ranger 7 returns increasingly high resolution pictures of the Moon's surface. The final image at bottom right was taken from a height of 5 km.

thened slightly, loosening its grip on the terminals and increasing the electrical resistance, hence the heat. Less than an hour later the spacecraft was dead.

There followed the events described in Ref. 4. I was replaced as Project Manager by Harris M. (Bud) Schurmeier, one of my best and oldest friends. We had gone through Caltech and Navy flight training together and shared recreations including skiing, surfing, sailing and soaring. He had headed JPL's Systems Division and was a perfect choice for the tough task of bringing Ranger through to a success – which he did, after one more exasperating failure. With the simplified mission of sending television pictures during lunar approach, Ranger 6 had a perfect launch and a perfect flight to the Moon, but then its cameras didn't send any pictures. The cause of the failure, though subtle, was ultimately discovered. At staging of the Atlas booster engines, a hot plasma cloud enveloped the vehicle and momentarily short-circuited some pins in the umbilical connector, causing the two high-powered Ranger video transmitters to turn on. This in itself would not have been serious, except that the vehicle was then passing through a region of ters were prone to arcing – which destroyed them both.

The Ranger failures brought into question not only our engineering philosophy and methods, but also the whole concept of JPL as a university laboratory involved in big, complicated system developments. However, cool heads prevailed. Under the steady hand of Dr. William H. Pickering, JPL stood off all threats, and on 31 July 1964 Ranger 7 provided the payoff: thousands of beautiful high-resolution pictures of the Moon. I'll never forget my first sight of the exquisite, soft details of the lunar surface in those Ranger video images. On the great day a reporter asked Pickering about the Laboratory's future and he replied with a grin, "I think it's improved!"

From then on we've never looked back. Rangers 8 and 9 sent more lovely Moon pictures. Surveyors (built, as were the Ranger payload modules, by industry in keeping with our original lunar-programme plan) began landing on and sampling the Moon. Lunar Orbiters, in a project managed by the NASA Langley Research Center, photographed the Moon's entire surface as a prelude to Apollo. Meanwhile, Mariners, Vikings,

Center) and Voyagers roamed inward and outward in the Solar System. Two Pioneers and two Voyagers have attained the third cosmic speed and are outbound to interstellar space.

After several failed attempts [9], the Soviets did achieve the longed-for lunar milestones – the first landing and the first orbit – with Luna 9 and 10 in 1966. Had we known that they were going to have so much trouble getting to the Moon, we need not have pressed so hard with Ranger.

While we wait for the upper stages of the Shuttle to materialize so that the United States can again fling spacecraft away from Earth, JPL's people have not been idle. Seasat, several Earth-orbital Shuttle payloads, and most recently the beautiful Dutch-American-British infrared astronomy mission, IRAS, all show the continuing vitality of the Laboratory, and Galileo, the Venus Radar Mapper and the Extreme Ultraviolet Explorer are signposts along our future path.

My own roles in these events have been varied, sometimes frustrating, but always interesting. In the mid-1960's I was assigned, as a few JPL people are at any given time, to a tour of duty in Washington, D.C. It was a marvellous experience for us and our children. When the tour ended we were invited to stay and hated to leave the excitements of the Capital and the beauty and variety of the East. But I am for deep space, and JPL remains the centre of deep-space exploration in the western world. Since our return, I have had several assignments in studying and developing our future missions. We studied lunar and martian rovers. We looked at prospects for lunar resources [12,13,14] and I was honoured to become a trustee of the Space Studies Institute headed by G. K. O'Neill. I proposed a micro-spacecraft made mostly out of silicon chips. People in my groups studied missions to every object in the Solar System including, of course, the Sun. Naturally one expects only a fraction of such studies and proposals to be implemented. In recent years, however, our frustration has been especially high. Studies of the Venus Radar Mapper, previously called VOIR, went on for more than a decade, and one mission that I like especially – the lunar geochemical polar orbiter [15], known in ESA's very similar proposals as POLO – has repeatedly failed to gain acceptance. But you can't play favourites in the future-missions game. Any venture that becomes the subject of a serious, funded study might be a winner. Right now we are examining two splendid astrophysical missions: an Earth-orbiting radio interferometer and an orbital submillimetre-wave observatory. I am sure that both will be launched in this century, if not by the US then by others.

As a sideline in recent years, I have been on Paul MacCready's team developing human-powered and solar-powered ultralight aircraft [16,17,18] including the Gossamer Condor and the Gossamer Albatross that won the Kremer Prizes. These efforts, a perfect synthesis of my interests in flying, sailing and innovative design, have reinforced the lessons of our deep-space projects: analyze carefully, then set demonstrably achievable objectives and stick to them. Keep up a fast pace and rigorously exclude distractions. Above all, enjoy the work and be prepared to give it your all. The link between playfulness and creativity, long known to observers of human behaviour, is central.

Lunar and planetary people are now in a peculiar state: our ideas and aspirations for deep-space missions, and our knowledge of how to do them, have far outrun our ability to convince our countrymen of their worth. Believing that the potential for worldwide public support is much greater than indicated by US or other government actions, two years ago Carl Sagan and Bruce Murray, then the Director of JPL founded The Planetary Society and invited me to be technical editor of its newsletter. It is a challenging and very enjoyable assignment.

The Future

What does it all mean? Apart from the beautiful science, the human adventure, and the endless engineering fun, is there a deeper significance to what I have here described? I think so. It is this: we happy ones with our deep-space colleagues in other countries (and people in certain other fields around the world), have found a way to practise the highest arts of large-scale technology without endangering a soul on planet Earth. Serenely I look to our future, confident that if this idea were to spread, better human lives would be lived both here and on the Moon.

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SOCIETY BOOKS

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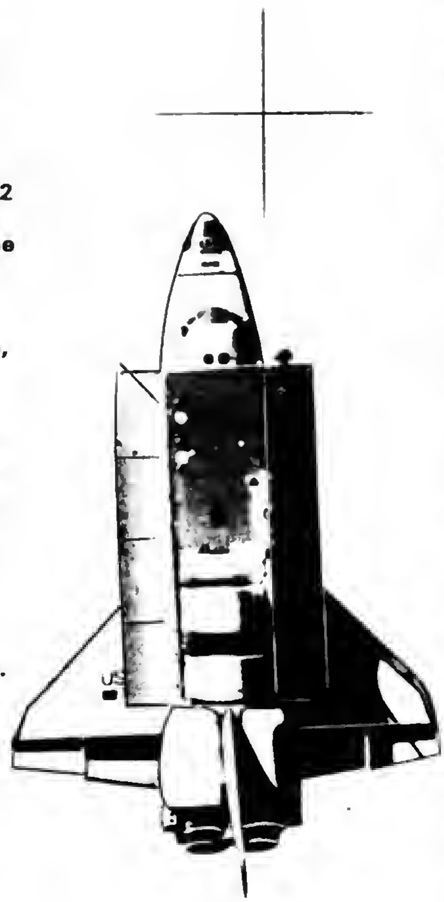

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An exciting progression of space achievements in the years following the Second World War led to Man's first landing on the Moon in 1969. Rockets for probing the upper atmosphere evolved into the space launchers we know today. Vanguard, Explorer, Atlas, Titan, Mercury, Gemini, Apollo – a succession of names to conjure up memories of the 50's and 60's when man was taking his first tentative steps into outer space.

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All of the books are available from: The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ, England

FROM THE SECRETARY'S DESK

Of all the Comets in the Sky...

A fascinating new addition to the Society's display cases is a coin, a silver denarius, from the time of Augustus Caesar. It features a bust of Julius Caesar with a comet above his brow. Julius was assassinated on the Ides of March i.e. 15th March 44BC. The comet (actually Halley's comet) appeared shortly afterwards. Shakespeare picked up the fact in his play "Julius Caesar" with the famous line, "When beggars die there are no comets seen." The comet was not seen before June, the month given by the Chinese, though Latin authors describe its brightness during the games instituted by Augustus in September of the same year. The idea of the star above the head of Julius (suggested by the appearance of the comet) was based on the idea that this bright visitor was really the soul of Julius ascending to Heaven.

Particularly interesting is the fact that the Wheel of History may shortly make a full turn, for the Giotto spacecraft is currently scheduled to fly past Halley's comet either on 14 March (my birthday!) or 15 March i.e. the Ides of March once again.

Members will have an opportunity of seeing Giotto under construction next May. Work is well advanced. Those planning to go on the trip to South Africa, particularly, will find the prospect of seeing the spacecraft being readied especially attractive. Those not so fortunate might take comfort from the two special issues of *JBIS* scheduled for 1984 (one has already appeared) featuring the comet. Each issue costs £2.

Bring Back the Acorns

Not everything has to be on crisis level. Some things are desirable just for nostalgia because they recall a pleasant or more harmonious age, or simply because they are nice things to do.

One such is the acorns (finials) which adorned the gates and railings of our premises long ago. The existence of these, or rather their non-existence, was raised once more when the question of repairing the front railings and re-hanging the gates came up for consideration.

The local Historic Buildings Department are keen to see restitution. They have provided details of suppliers so we may soon be able to discover if reproductions can be made and fitted.

Historical Material

I hope every member will support the efforts of both our History and Library Committees in trying to secure for us space items of all sorts. Frequently, owners of suitable material are unaware of its interest. This is a role our Society wants to play — to be the Guardian and safe keeper of material which, even if not of intrinsic value now, could be of great interest in future years. Members who have such items, or could get hold of them, are urged to send us details.

Useful items can come from the most out-of-the way places and need not even be concerned solely with recent space adventures. For example, a local department store in London a few years ago had on display an empty wine bottle bearing the impression of a comet (probably the one of 1843) and clearly labled "Comet wine." We also learned recently of a medallion issued to commemorate the 1910 return of Halley's comet. These are examples. Similar material *must* be around. Please help if you can.

Anticipating all this, Max Wholey has been appointed Archivist by the Library Committee. All he needs now are some archives.

Man About Town

Many visitors to our Offices take the opportunity to seek advice and guidance about other matters stemming from their stay e.g. restaurants, places to visit and the like, and are (so we fondly imagine) suitably impressed by the data furnished in return.

It wasn't always so. Our first visitors, many years ago, had to take us in tow to see all the sights of London for, being typical Londoners, we had never seen any of the tourist spots. Thus baptised, we became adept at dealing with other questions though some of the shopping items hit below the belt. We soon found the answer to "where does one buy china owls?" but, by the time we came up with the reply to "where can I buy a suit of armour?", we had forgotten who had wanted to know.

We soon discovered the index at the Design Centre in Haymarket solved most of our problems, besides turning up a range of very attractive ideas we were able to boast about afterwards.

The Hole Truth

Contemplating the large hole where our former offices at Bessborough Gardens once stood brought back many memories. One's eye was attracted, first, to a sign indicating that it was now part of a site offered to a developer for sale, thus ending the saga of the never-ending ever-grander schemes put forward by the Crown Estate Commissioners to bolster support while they ejected the existing tenants. At one time it was to include a yachting marina, pubs and a river walk nearby, a major conference centre and buildings of such beauty that visitors would come from far and wide.

At first we occupied only two rooms on the ground floor of 12, Bessborough Gardens. These were acquired in March 1952 at a rent of £150 p.a. As the first floor was then being used for business purposes by another tenant, our mutual correspondence soon became inextricably mixed.

Our own post frequently included letters, mainly from Central Africa, requesting charms in the shapes of Hindu Gods. These, apparently, had magical qualities which made them just the thing for passing an exam, winning the affections of a lady, job promotion, and similar problems which afflict most of us. The cost was reasonable.

Presumably, some of our space correspondence got mixed too, with catalogues of charms sent in reply. If so, our correspondents must have been well satisfied. We never received a single letter of complaint.

Stonefaced

One of our members recently had good cause to be perplexed. He had visited Harlow Tower, a 19th century folly near Harrogate, and discovered the Society's badge engraved in 45 cm thick stonework!

The story behind it concerned a group of Yorkshire members who lived near Harrogate about 25 years ago and who wanted a local meeting place. They thought the tower, which had an adjacent side building, could provide suitable amenities, particularly if the open top of the tower could be covered over. And covered over it duly was, with a large circular rail and a rotating observatory dome on top. The idea was to make astronomical observations, using the telescopes of local members.

Unfortunately, a severe gale put paid to it all, not only by demolishing nearby trees but also by lifting the heavy dome from its moorings and leaving it overhanging both the tower and a public pathway underneath.

At HQ, our first notification of danger came with a telephone call from the Town Clerk's Office at Harrogate. They owned the tower and surrounding land and had leased it to local members who, unfortunately, had then melted away. Arriving hotfoot at the Council's offices to sort out the mess, I was confronted with a letter signed by some of the erstwhile local members purporting to bind the Society to all liabilities stemming from the use of the tower, a liability happily conceived and entered into without reference to the Council or anyone else, least of all those who would have to pick up the pieces afterwards.

The Society found itself facing a bill for restoration which it could not possibly afford, particularly if death or injury should result to passers-by. Fortunately, insurance cover on the tower taken out at HQ helped to ensure that the offending and highly dangerous dome was removed at the first opportunity.

It was a salutory experience but, in the rush to settle affairs, the carving in the stonework (or "de-facing" of a monument as the Council might have it) was overlooked. There, apparently, it remains no doubt to the consternation of future archeologists.

What's in a Name

One of the biggest time-consumers to afflict our Society over the years has been discussion on whether to change its name. Some people must have an inner urge for change that needs to be satisfied, hence extreme and quite unprovable assertions that the Society would be stronger today if it had been called something else, and ignoring the fact that it has gained a worldwide reputation nonetheless.

Indeed, the outside world takes a contrary view. Frequently we have experienced the problem of other groups attempting to take over the very name that others want to discard! For example, "Astounding Science Fiction" in 15 Novmber 1958 advertised plans for forming an Interplanetary Exploration Society, publishing an "Interplanetary Journal." Our solicitors persuaded them to change their tune and nothing more was heard. Presumably, no alternative names were good enough.

In February 1966 a British Interplanetary Association appeared in Birmingham. This, too, was queried by our solicitors with the result that they changed their name to the "Cosmic Interplanetary Association" and shortly afterwards vanished from the scene. Another organisation which appeared later was called the "British Interplanetary Space Travel Research." They, too, were asked to make a change.

Sometimes, the name selected is not intended to compete with the Society but, as the legal-beagles have

The fated Harlow Tower near Harrogate.

individual chose a name which sounded like an official Government Establishment concerned with rocketry. He printed headed paper to match and had a high old time before everyone cottoned on. Even international space agencies do not remain unscathed, but that's another story.

The Society, itself, found difficulty. In September 1953, because we had been known simply as the "Interplanetary Society" for decades, we made an application to register this under the Business Names Act of 1916. It was refused on the grounds that it too closely resembled that of the BIS! A similar problem arose when the Society decided some time later, to form a companion body, the British Rocket Society. The same applied when the idea appeared for a British Astronautical Society. This vanished as well.

Hell in Heaven

My contemplation of the god-like beings of *Helionde,* mentioned earlier, has suffered a severe reverse. Further reading brought to light a learned tract "An Enquiry into the Nature and Place of Hell" printed by W. Bower for W. Taylor at the *Ship* in Pater-Noster-Row, (1714) which shows, unequivocably, that the Sun is really the Biblical Hell. To make the point, included is a drawing which shows some of the souls in torment peering out through the relatively cool regions known as sunspots.

There the matter now rests.

Catonaut

A space theme with a difference took place at the Supreme Cat Show in Birmingham last January when John Burley (Fellow) displayed one of his Burmese cats. The cat-pen consisted of a back piece, side pieces and a base made up to simulate the surface of the Moon. Above was a starry background superimposed on which was an 20 cm diameter "Earth." To the left was a cardboard "lunar lander." The essential litter tray contained cardboard sides dressed up to simulate a crater on the Moon!

It was a Champion out of this world, right enough.

ASTRONAUTICS AT BUDAPEST

In the February and March issues we carried the first parts of a report on last year's IAF Congress in Budapest. Here we conclude the report with individual looks at some of the sessions.

IAF STUDENT CONFERENCE

The student conference was divided into two sessions held on the mornings of 10th and 11th October. Policemen, it is said, look younger as one gets older. At this Conference the reverse was true, the students appeared older or, rather, more mature than I remember from my University days. A large proportion of the 17 papers presented came from Hungary (3) and nearby countries: Czechoslovakia (2), Bulgaria (1) and Yugoslavia (1). The rest came from China (3), France (3) and the USA (2) leaving a surprising lack of representation from students in Russia, Germany, Japan and the rest of the world.

The majority of the papers were theoretical in nature, and their content ranged from the consideration of the 3-dimensional inverse problem by V. Varadi of the Lorand-Eotvos University in Budapest to a study of a use for the Space Shuttle at the end of its 100 planned missions. The latter paper, by a group from the Observatory and Planetarium in Prague, suggested using the Shuttle on its last mission as a cheap, flexible space station with a one year life. This station would be replenished as necessary during the year's mission. One of the most interesting papers was by S. Rahman from Texas A and M University. It described scale modelling experiments carried out to evaluate ideas proposed to alleviate the ice-formation problem on the Shuttle's external tank. Ice, formed on this tank during its loading, etc., with cyrogenic propellent, is stripped off during launch and has damaged some heat tiles on the Orbiter. This paper won the undergraduate prize of the conference.

At the start of the second session five cosmonauts — Svetlana Savitskaya (the second woman in space), Anotoly Berezovoi and Konstantin Feoktistov from the USSR, George Ivanov from Bulgaria and Dumitru Prunariu from Rumania — answered questions from the audience. One questioner asked what the cosmonauts thought about the Space Shuttle. Feoktistov, veteran of the 1964 Voskhod flight, said that as a piece of engineering it was excellent but it was not a cheap launch system.

An average of about 30 delegates attended each session although numbers swelled appreciably while the cosmonauts were present.

E.J. BECKLAKE

SPACE SAFETY AND RESCUE

Man-made orbital debris is one of the most rapidly changing elements of the near-space environment. The lead paper was that of Luboš Perek, past-President IAF, whose personal attendance at the Congress was prevented by the completely unanticipated denial of travel permission the day before his planned departure. Dr. Perek coupled the need to adopt measures concerning the safety of space activities with the inter-related concern for the protection of the environment — and the need to do so without delay. Among the concerns cited were traffic separation to avoid collisions with space debris; the bringing into being of a series of international agreements to keep only active satellites in the heavily-trafficked orbital belts, to designate disposal orbits for inactive satellites, to set design regulations to minimise the accumulation of space debris, to set standards on the quality of technical equipment and the competence of personnel

Fred Ordway, centre, resolves a technical point with Kristan Lattu, while Les Shepherd looks on (right).

in charge of the launching and operation of spacecraft (particularly in view of the entry of non-State consortia in these operations), timely access to full and updated sets of orbital data for all space objects, and extension of studies (on avoidance of harmful contamination of the Earth resulting from the introduction of extraterrestrial matter) to include the entire spectrum of polluting effects connected with space activity. Dr. Perek called upon the IAA Committee on Space Safety & Rescue to embark on a systematic study of all problems that have not as yet been regulated (in 1967 Outer Space Treaty and subsequent agreements adopted by the United Nations). The purpose of the study would be to determine whether additional regulation is desirable or not. He made the further suggestion that the outcome of the study might become a position paper of the IAA on the subject. As a footnote the paper "Man-Made Space Debris: Implications for the Future," presented at the Space Safety and Rescue Symposium in 1982 by Wolfe, Chobotov, Bond was cited.

The session programme then considered these matters from the points of view of defining and modelling the space debris hazard population, design options to increase space system vulnerability in a debris environment, the legal regime assurance of safety accountability and the comparative effectiveness of several international control concepts from point of view of economic motivation and varied other institutional considerations.

An overview paper on radiation hazards in Earth orbit expressed concern that it may not be possible to reduce the radiation hazard for prolonged flights in GEO (accentuated in EVA) to totally acceptable levels due to the significant uncertainties in the setting of exposure limits in respect to the natural particle radiation environment (geomagnetically trapped electrons and protons, transient energetic solar flare protons, and solar and galactic cosmic rays) and also to two conceptual man-made radiation environments: leakage radiation (neutrons and gammas) from a nuclear reactor to supply power-intensive space projects and high altitude nuclear explosions (injection and geomagnetic trapping of the beta particles).

G.W. HEATH

IAA HISTORY SYMPOSIUM

Fourteen papers were presented during this symposium held on the mornings of the 12th and 14th October. The extra session greatly enhanced the proceedings and enabled a realistic time to be devoted to the presentations. They were well attended with audiences of up to 50 on occasions and we were honoured on the second morning by the presence of Professor Herman Oberth, an Honorary Fellow of the Society.

The Symposium began with a paper dedicated to the memory of Dr. Olgierd Wolczek, the Polish scientist and BIS Fellow who died last year. Olgierd will be remembered for

Opening the Congress in Budapest.

a lifetime of publicising astronautics as well as for his scientific publications which ranged from studies of nuclear energy for rocketry, planetology, the impact of astronautics on science through to studies of life in the Universe.

Major highlights were papers on "The British Interplanetary Society: The first 50 years (1933-1983)" by G.V.E. Thompson and Dr. L.R. Shepherd, the work of the Rumanian inventor Alexandru Churcu by Lagauescu *et al*, "A Comparative Study of the Evolution of Manned and Unmanned Spaceflight Operations" by Kristan Lattu and a study of Korean rockets from 1377 to 1600 by Chae.

The BIS paper traced the history of our Society from its first meeting on Friday 13 October 1933 at Dale Street in Liverpool and described the important part it played in the founding of the IAF. This was inaugurated during the second International Astronautical Congress, held in London during September 1951 when the BIS acted as host.

The paper on Alexandru Churcu, read by F. Zaganescu from Rumania, described the experiments carried out in Paris during 1886-1887 by this Rumanian exile with the help of a Frenchman called Puisson on a "Jet Propulsion Engine." Churcu designed, built and tested this device on a boat and a small railcar in Paris, and one of his original engines is now to be seen at the Technical Museum in Bucharest. This paper adds greatly to our knowlege of early reaction devices as does Chae's paper on Korean rocketry. Chae, from the Mississippi State University in the USA, could not attend the Symposium and his paper was read by Mitchell Sharpe from the Alabama Space and Rocket Center at Huntsville. The paper contains the first modern study of Korean rockets from 1377 to 1600. Using descriptions found in ancient Korean documents, modern working drawings were made and these were used to construct and fire modern copies of the early Korean rockets. These replicas can be seen at the Hang-gu Castle Memorial Museum near Seoul in Korea. Kristan Lattu's paper on "Spaceflight Operations and Controls" opens up a new avenue in the history of astronautics. Prior to this historians had concentrated mainly on the spacecraft, rockets and hardware in general. Lattu's paper looked at the ground control operations that are needed to run various space programmes and how they have evolved from the early days of space flight.

Other papers included one on the early years of communication satellites by Dr. B.I. Edelson (NASA). This traced the development of such satellites from 1958 to 1964, when projects like Score, Carrier, Echo and Telstar hit the headlines and succeeded in making satellite communication not only possible but practical and profitable. The history of the Hungarian Astronautical Society, the host society for this year's Congress, was received in a paper by I. Nagy. It was followed by two papers from Russia — by G. Masing entitled "On Some Regularities of the Development of Solid Propellent Rocket Engines" and by B. Rauschenbach which discussed the work of Russia's Jet Propulsion Research Institute formed 50 years ago. The latter paper traced the history of the Jet Institute from its origins in the joint efforts of the Gas Dynamics Laboratory in Leningrad and the Group for the Study of Jet Propulsion (GIRD) in Moscow, through to the end of the Second World War when the Institute effectively ceased to exist in its original form.

The second session ended with four interesting papers from the USA. The first three dealt with the liquid propellent rocket work carried out by the US Navy during World War II (author — R. Truax); Project Rover, the US Nuclear Rocket Programme which lasted from the mid-1950's until 1972 (N. Dewar) and some reminiscences of an early rocketeer (B. Smith). The fourth by F. Ordway and F. Winter entitled "The Reaction Motors Division Thikol (Chemical) Corporation" was the second half of the history of the Corporation. The first half was presented at last year's Symposium.

E.J. BECKLAKE

COST REDUCTION IN SPACE OPERATIONS

This session was part of the 13th Symposium on Space Economic and Benefits, organised by the relevant Committee of the IAA. Two major aspects were dealt with in the seven papers presented: the traditional theme of cost reduction and economics of communication satellite systems, and commercial space activities, a new subject of increasing interest.

A paper of D. Kivell (National Broadcasting Company, New York) explained the analyses performed by NBC to identify the most economic means for TV programme distribution — with the recent decision for their own Ku-band satellite system with 170 ground stations.

Two papers, by J. Vandenkerckhove (ESA, Paris) and D.E. Koelle (MBB, Ottobrunn) respectively, dealt with the specific space segment cost (satellite and launch cost per communic-

ation channel) but produced somewhat different results. While the improving cost efficiency with growing spacecraft size was demonstrated by both speakers, Dr. Vandenkerckhove was sceptical about further improvements for satellites beyond 2,500 kg mass in GEO. Dr. Koelle, on the other hand, showed essential further improvements for satellites of 4,500 kg and beyond. The optimum satellite size would depend very much on the total communications capacity conceived for a particular system.

On the subject of Space Commercialization, Prof. Logsdon (George Washington University) warned ebout too much optimism, though there were interesting long-term prospects if developed carefully.

B. Raab (Fairchild Industries) reported on a very ambitious $200 million venture of his company in the planned development of "Leasecraft," a 5,000 kg space platform to be leased to payload customers for a charge of $3–5 million per month (minimum duration 6 m). The platform would provide all services, including power up to 7 kW.

The third paper in this area, presented by D.E. Cherhout (GD/Convair), dealt with the development of a commercial Centaur family. It discussed the difference between the past government contract mode and the direct sale of this launch vehicle to commercial customers, in competition to Ariane, for example.

D.E. KOELLE

RESPONSE DISASTER/DISTRESS

The clear messages signalled from this session were that: 1. requirements for Earth distress applications are now being stated in truly user-oriented terms, in place of concepts previously having been put forward by the developers of remote sensing and communications satellites; 2. order of magnitude contributions to air safety can be expected with the realisation of satellite-based navigation with its precise position location provisions.

This was put in clear, broad perspective by the Rosetti paper and the thoughtful paper presented by Blanchard giving a useful basis for assessing the advantages and disadvantages of the range of newer distress-alerting and position location systems in comparison with the reliability and accommodations provided by the earlier-developed Transit system.

Among those attending the session were liaison representatives of national and international distress-response agencies who noted that the broad scope and representation at the session offered unmatched opportunity for significant exchange amongst developers of systems and users.

G.W. HEATH

MOBILE COMMUNICATIONS SERVICES

Five papers were scheduled for presentation but, regrettably, two were not presented, including one which was to have described the concept for providing aeronautical satellite data communications. This was unfortunate because Inmarsat is currently studying the feasibility of providing aeronautical communications with its second-generation satellites from 1988 onwards and many people were interested in a description of the type of service deemed feasible.

The three remaining papers were submitted by staff from ESA. They covered a range of topics, including description of the Marecs 1 satellite and some of its technical challenges and solutions, a review of possible system concepts for mobile communications in the polar regions, and a description of Navsat, a dedicated worldwide civil navigation satellite system currently being proposed by ESA.

For some time now, various bodies have been investigating the feasibility of providing mobile satellite communications in the polar regions. The paper by G. Berretta provided a good overview of the topic ranging from the potential commercial demand to the applications for distress and safety and public correspondence services. It was interesting to note that the peper identified a likely potential commercial requirement in the Antarctic region later this century if commercial exploitation of hydrocarbon and fishing resources is possible. The paper examined all potential orbits both below and above the Van Alan belt which might be used for this purpose. It identified the number of setellites which would be required in various orbital configurations to provide continuous coverage in the polar regions beyond the area served by geostationary satellites, and the technical considerations to be considered to make a polar orbiting satellite system compatible with the existing Inmarsat system. The paper did not reach a definitive conclusion as to the optimum orbit or number of satellites that would be required. This will be difficult until commercial and user requirements are better defined.

The Marecs 1 paper by D. Campbell reviewed the historial development of the Marecs satellite and its success to date. Some of the technical challenges faced by the development team were highlighted as were the solutions and remedies identified, implemented and subsequently proved in both the testing and operational deployment of the satellite. Notable amongst these was the use of solid state power amplifiers, expected to have significant potential in future spot beam satellites. Another topic was the use of a shaped parabolic antenna to ensure uniform signal reception over the whole Earth disc. Multipaction and passive intermodulation problems, resulting from use of the single antenna for up and down links at L-band between the ship and satellite were identified and successfully resolved.

The Navsat paper by C. Rosetti provided a comprehensive overview of the worldwide civil satellite navigation system currently under study by ESA. It explored the need and financial benefits to be derived by replacing all of the existing terrestrial radio navigation system, such as Loran, Omega, Decca, DME/VOR, NDB etc., with a single worldwide civil satellite system.

An interesting concept put forward at the end of the paper is the possibility of piggy-backing the Navsat on other multimission satellites in order to minimise costs.

A.F. GHAIS

SPACE EXPLORATION

The symposium was coordinated by J. Casani (USA) and G. Riviere (France) and was held in three sessions: "Unmanned Solar System Exploretion," "Scientific Spacecraft" and "Advanced Technology for Scientific Space Research." Sixteen papers were presented in total.

The first three papers, "The AMSAT Mission to the Asteroid Belt" by K. Meinzer, "Internationally Supported Data Acquisition for Solar System Exploration in the 1990's" by M.S. Reid *et al*, and "Galileo Spacecraft Integration" by R.J. Spehalski, were well related to the theme of the Congress.

The proposition of international collaboration in data acquisition appears to be practical, cost effective, and beneficial. It has been formally proposed by JPL, and further study is very likely.

The proposition to investigate the layered structure of Phobos as described by E. Illés *et al* would be very interesting to pursue on the next Mars mission. This is a new idea with very intriguing implications.

The AMSAT Mission was reported to involve a cost of only $4 million. If this proves to be the case, it should establish a new precedent for space science mission implementation.

New information on the surface roughness and slopes was presented in a Soviet paper by A.G. Pavelyev *et al* for five regions on Venus. General agreement was found with the Pioneer Venus data.

Spehalski's paper provided recommendations on establishing hardware interfaces for international programmes. The recommendations and conclusions were drawn from the recent Galileo experience involving cooperation between

NASA and West Germany.

Highlights from Session G.2

All of the papers in the second session, held on 13 October, were related to some kind of international cooperation and fitted very well with the spirit of the Congress. The first two papers, describing the Soviet VEGA Halley probes and the French participation, covered the scientific instrumentation provided by Hungarian and French institutes. The Soviet paper by G.A. Avanesov *et al* described the scan platform and the TV camera associated, while the second, by J. Runavot and A. Ammar of CNES, described the rest of the instrumentation.

The two other papers, describing the German Rosat observatory and the Swedish Viking satellite, were good examples of the design of scientific spacecraft, starting from the definition of the mission, identification of scientific requirements, and finding of the technical solutions.

The two final papers, "Effects of Small-Scale Plasma Disturbance on Spacecraft Potential" by K.B. Serafimov *et al* and "Measurement of Potential Aboard Spacecraft" by S. Chapkunov *et al*, were closely related on the problem of electrical disturbances on spacecraft. The former presents results obtained by the satellite Bulgaria 1300 which will be helpful for future scientific instrumentation on-board spacecraft and data perturbation analysis. The latter presents a new instrument for measuring electrical potential on spacecraft voids, which will be flown by 1988.

In the third session, the paper "A Space Telescope Able to See the Planets, and Even the Satellites, Around the Nearest Stars" presented an interesting idea for using a screen in conjunction with a space telescope to investigate planets about stars. The idea needs more development in order to receive serious consideration.

"Satellite Technology Developments in Gravity Research" by V.L. Pisacane gave a good survey of past work in the USA on gravity research and a summary of new or proposed projects using the latest technology, including electrically suspended accelerometers and cyrogenic techniques.

"Orbital Gravity Gradiometry Through Differential Micro-Accelerometry" by A. Bernard *et al* was a thorough presentation of a gravity gradient measurement technique using differential accelerometry that promises three orders of magnitude improvement over prior French experience.

The paper by A. Perret of CNES was a presentation of a theoretical technique for the determination of the mass of small asteroids by measuring the perturbation of the trajectory of a small mass. This concept needs further work to determine improvement over other techniques and feasibility.

The final paper, by Ye. T. Dub of the USSR Academy of Sciences, proposed a differential Fourier transformation method for on-board satellite electromagnetic wavespectrum analysis. The technique permits parallel analysis of different processes and the determination of amplitude and frequency of polyharmonical process components.

JOHN CASANI

VOICES FROM THE PAST

We were extremely pleased to see at the Congress Professor Herman Oberth (a Fellow of the Society and doyen of the space pioneers) still as spritely as ever. It reminded us of a letter far predating the IAF but concerned with international collaboration in space which we now reproduce for posterity. It is very interesting to note that M. Esnault-Pelterie, one of the signatories was later to become a BIS Fellow.

Herr Hermann Oberth,

January 23, 1931

President,
Verein fur Raumschiffahrt,
Scharnhorststrasse, 24,
Berlin, N.W. 40, Germany.

Dear Sir:

May we present for your attention and interest the following proposal for the formation of an International Commission for Astronautics?

We believe, as the result of a number of conferences during the present visit of M. Esnault-Pelterie to America, that the progress of astronautics, involving as it does, so much that is new in every science known to man, will be hastened by co-operation between the scientist working on the problem throughout the world, and by a free exchange of information and plans for research.

We believe that the International Commission which may be formed by representatives from each of the national groups could:

1. Stimulate and assist in the formation of national organizations where now exists, as in Britain, Italy, the South American countries, Japan, etc.
2. Act as a central clearing house for information and data of all kinds bearing on the interplanetary problem, as may be desired by the member societies and the public.
3. Facilitate the exchange of the results of experiments and research so that international cooperation of men and nations in solving the multifold problems may be made, and scientists will not spend time in pursuing fruitless paths of research.
4. Stimulate the greatest possible number of minds to work both cooperatively and independently on the vast number of problems to be solved, and to induce as far as possible a central planning in the solutions of the problems. The international organization may thus keep the world informed of the progress of the solutions of these problems and of those that are still in urgent need of solution.
5. Provide an international bureau from whom the people and nations of the world may ask advice on the interplanetary problem. It is believed that thru the operation of this commission over a number of years exchange of information, as confidence grows there will be a gradual levelling of national distrust and the problems preliminary to the actual building of a space ship will be more quickly solved. The world will then have an international organization, free from national bias, whose personnel, approved by the world may be ultimately entrusted with the funds and power necessary to the building of the first space ship.

May we recommend this to the earnest attention of your Society. We would be very pleased to hear from you (M. Esnault-Peterie at Boulogne-sur-Seine, France, after February 10 and Mr. Lasser at the American Interplanetary Society, 302 West 22nd Street, New York) and have your views on this proposal? We believe that after a frank exchange of opinions on what can be done to best promote astronautics, a constitution of the international commission may be formed for circulation among the national groups for their consideration and approval.

Very truly yours,

Robert Esnault-Peterie
for the French Committee for Astronautics

David Lasser
for the American Interplanetary Society

SATELLITE DIGEST-172

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

Robert D. Christy

Continued from the March issue

METEOR 2(10) 1983-109A, 14452

Launched: 0900, 28 Oct 1983 from Plesetsk by A-1.
Spacecraft data: Cylindrical body with two, Sun-seeking solar panels, length about 5 m, diameter about 1.5 m and mass around 2200 kg.
Mission: Meteorological satellite returning scanning radiometer images of cloud cover and the Earth's surface.
Orbit: 752 x 888 km, 101.36 min, 81.17 deg.

COSMOS 1507 1983-110A, 14450

Launched: 0830, 29 Oct 1983 from Tyuratam by F-1.
Spacecraft data: Not available but probably several tonnes mass.
Mission: Electronic reconnaissance covering shipping movements.
Orbit: 433 x 442 km, 93.35 min, 65.06 deg, maintained by low thrust motor.

COSMOS 1508 1983-111A, 14483

Launched: 1230, 11 Nov 1983 from Plesetsk by C-1.
Spacecraft data: Not available but may be similar to the navigation satellites.
Mission: Possibly ionospheric research.
Orbit: 397 x 1964 km, 109.05 min, 82.93 deg.

COSMOS 1509 1983-112A, 14490

Launched: 1215, 17 Nov 1983 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument unit and cylindrical, supplementary payload at the forward end. Length about 6 m, diameter (max) 2.4 m, and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 225 x 290 km, 89.70 min, 72.86 deg.

OPS 1294 1983-113A, 14506

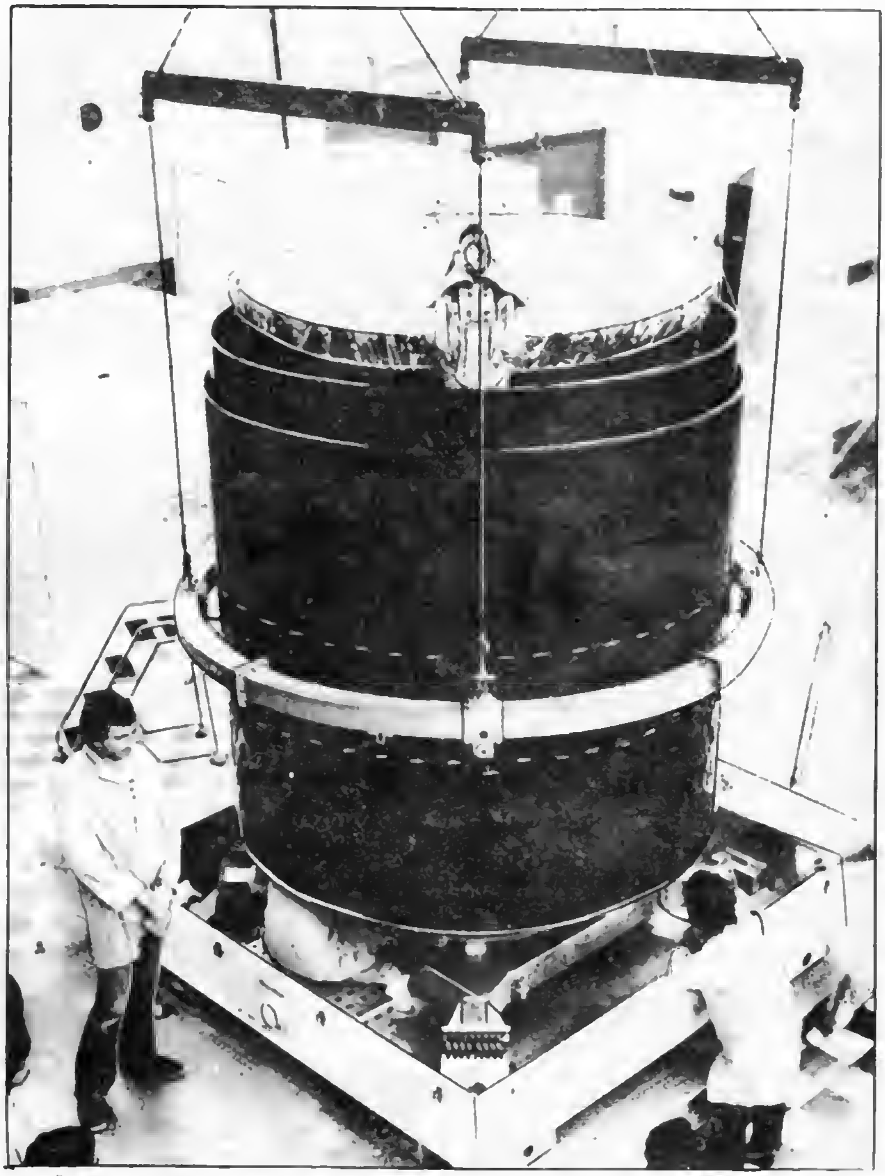
Launched: 0630, 18 Nov 1983 from Vandenberg Air Force Base by Atlas F.
Spacecraft data: Irregular cylinder with solar panel, approx 6 m long, 2 m diameter, mass around 750 kg.
Mission: USAF meteorological satellite.
Orbit: 814 x 831 km, 101.42 min, 98.74 deg.

MOLNIYA 1(59) 1983-114A, 14516

Launched: 1646, 18 Nov 1983 from Plesetsk by A-2-e.
Spacecraft data: Cylindrical body housing instrumentation and the payload surmounted by a conical motor section; power is provided by a 'windmill' of six solar panels, overall length 3.4 m, diameter 1.6 m and mass around 1800 kg.
Mission: Communications satellite to help operate long distance telephone and telegraph communications, and broadcasting of Central TV to Orbita receiving stations in the Soviet far north, the Soviet far east and central Asia.
Orbit: Injected from a low parking orbit into an elliptical one of 442 x 39145 km, 702.32 min, 62.81 deg, later raised to 464 x 39894 km, 717.85 min, 62.82 deg to ensure daily ground track repeats.

COSMOS 1510 1983-115A, 14521

Launched: 1234, 24 Nov 1983 from Plesetsk by C-1.
Spacecraft data: Not available but may be similar to the navigation satellites.
Mission: Possibly geodetic.
Orbit: 1479 x 1524 km, 116.04 min, 73.62 deg.



The Shuttle mission in early February successfully orbited two communications satellites, Westar 6 and Palapa. However, both satellites were lost when their Payload Assist Modules failed, stranding them far below the required geostationary orbit. At present (mid-February), the belief is that both PAM nozzles burned through. NASA are investigating the possibility of rescuing the satellites next year although it would not be an easy job. They are spinning at 50 rpm, carry no grappling points for the Shuttle's robot arm, and are beyond the Shuttle's reach. The latter problem would be solved if ground controllers can use the satellites own small thrusters to bring them back into lower orbits. Present estimates suggest that the craft can survive for up to two years. Their value means that it would not be worth the effort of launching a Shuttle dedicated to their rescue alone; it would have to be part of an existing mission. The picture shows Westar, with its dish antenna folded down. NASA

BOOK NOTICES

McGrew Hill Encyclopedie of Astronomy
Ed. S.P. Parker, McGraw Hill, 450pp, 1983, £36.25.

The constellations were recognised as early as 3000 8C and the Egyptians were using calenders based on solar events by 2000 8C. 8ut, even though systematic observations of the heavens have been made for thousands of years the major increases in our astronomical knowledge have all taken place over the past few decades, brought about by revolutionary developments in instruments and methods of observation.

This encyclopedia provides up-to-date coverage of what is now a dynamic field of science, including references not only to the instruments and tools used to obtain astronomical data but also to models and theories which attempt to understand what is observed.

A total of 230 articles have been selected from an earlier and more general encyclopedia in 1982, to which have been added some 400 photographs, charts, etc. The entries themselves are more than simple descriptions. Most are really short articles, arranged in alphabetical subject order. Most include a bibliography and cross-referencing is used extensively.

The encyclopedia does not pretend to be comprehensive as regards astronautics as distinct from astronomical matters but, nevertheless, it embraces a substantial number of entries relating to space activities. These greatly add to its interest and usefulness.

Eddington
S. Chandrasekhar, Cambridge Univ. Press, 64pp, 1983, £7.50.

This monograph assesses the work of Arthur Stanley Eddington (1882-1944), one of the world's most distinguished estrophysists.

Undoubtedly, Eddington's most significant contributions to the physical sciences were the founding of modern theoretical astrophysics and creating the discipline of the structure, constitution and evolution of the stars. His interest in the internal constitution of the stars stemmed from efforts to find an explanation for stellar variability and the period-luminosity relation of Cepheids which thus led to the pulsation theory, although his analysis did not yield the correct phase relationships. Interests in galactic dynamics converged in his prediction that the radial velocities determined from interstellar absorption-lines must show, in their dependence on galactic latitude, an amplitude of one-half of that shown by the stellar absorption lines, a prediction later beautifully confirmed observationally.

.Eddington was a great expositor and exponent of the theory of general relativity. He undertook a major role in the expedition to observe the total solar eclipse of 29 Mey 1919, with the express purpose of verifying the prediction of the deflection of light by a gravitational field. The results of the expedition attracted world-wide attention in publicising this new conception of the nature of gravity and the Universe.

There is a good story about Eddington. He was approached with the remark "Professor Eddington, you must be one of three persons in the world who understands general relativity." Eddington demurred. On being told "Don't be modest," Eddington replied, "On the contrary, I'm trying to think who the third person is!"

Most of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

The Modern Internetionel Lew of Outer Spece
C.Q. Christol, Pergamon Press, 132pp, 1982, $85.

The growing exploitation of outer space, and its resources, shows how necessary it is to extend a world rule of law to such activities as quickly as possible. Lawyers who have addressed themselves to the task have frequently had to focus on more immediate issues, such as the liability for damage by spacecraft, though they have also considered some of the more remote prospects, e.g. stemming from exploitation of the natural resources of the Moon. Five important agreements have already been drafted at the UN, four of which have come into force, so the basis for a generally-accepted scheme of space law already exists.

The present volume attempts to identify the interests, values, wants and needs of those who seek an international legal basis to carry some of the burden relating to space activities. The four major agreements already concluded are dealt with in some detail. First is the 1967 'principles' treaty, followed by the 1968 rescue and return agreement and, in 1972, by the development of international space law relating to damage caused by space objects. A further matter which stemmed from this was the protection of space from contamination and pollution. The 1975 convention was on registration of space vehicles and in 1979, agreement was sought about the activities of States on the Moon and on other celestial bodies i.e. the so-called "Moon Treaty," which, initially, provoked a number of objections.

Many areas have still to be tackled though most are frequently discussed both officially and privately. Direct TV broadcasting is a current example for which an early solution is being sought, though remote sensing comes a close second. The same will doubtless soon apply to the use of nuclear power sources in outer space as well as to the future use of space transportation systems.

Soler-Terrestrial Physics: Principles and Theoretical Foundetions
Eds. R.L. Carovillano & J.M. Forbes, D. Reidel Publishing Co., 859pp, 1983, £115.

The volume examines the theoretical foundations for various components and processes of the solar-terrestrial system. Comprehensive treatment is provided in the areas of magnetohydrodynamics, kenetic theory, plasma waves and instabilities, plasma turbulence, planetary fluid dynamics, electrodynemics and photochemistry. Many important applications are developed directly from the basic theory thus provided, so bringing the reader up to date on some of the current problems in the field.

The book is based on the proceedings of a meeting held in 1982 and, although the scope is large and necessarily involves many contributors, topical coverage with suitable overlap and continuity is achieved.

The volume is designed as a text for a graduate course in solar-terrestrial physics or as a supplementry text for e course emphasising some of the special aspects of solar system physics. Readers will need a background in electromagenetic theory and elementary plasma physics if they are to derive the greatest benefit from what is a solidly-prepared work.

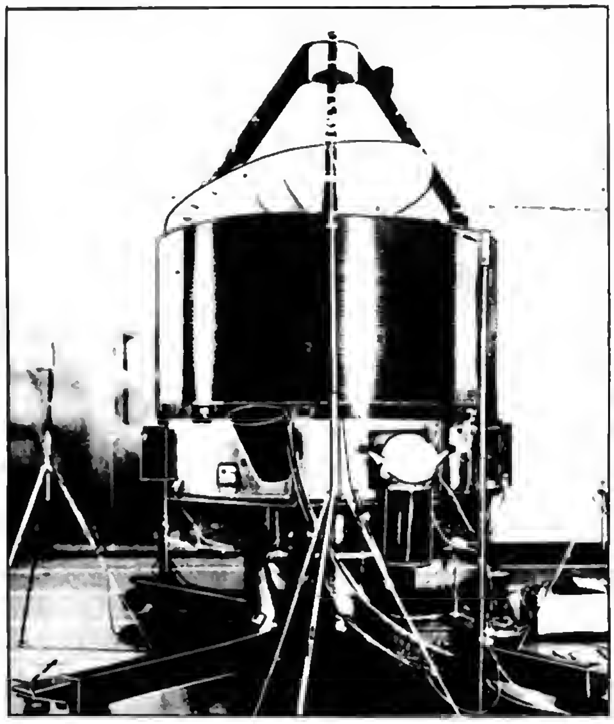
AN OPPORTUNITY TO SEE SPACE HISTORY IN THE MAKING

HALLEY'S COMET PROBE VISIT

When Halley's Comet plunges past the Sun in February 1986 it will be heading towards a meeting with several spacecraft from Planet Earth. One of these will be Europe's *Giotto* probe.

Society members now have the opportunity of visiting British Aerospace in Bristol to see this unique craft under construction. This is a once-in-a-lifetime opportunity to inspect the probe that will provide Man with his first close-up views of these celestial wanderers, and of particular interest to those who plan to go on the Halley's comet tour to South Africa later on.

Since the party has to be limited in numbers, places will be allocated on a first-come-first-served basis. The visit will take place on Wednesday, **23 May 1984** from 4.00 to 7.00 p.m. Registration forms can be obtained from the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Rd, London SW8 1SZ. Please enclose sae.



The Giotto structural model undergoing acoustic tests.

spaceflight

Spaceflight is published monthly for the members of the British Interplanetary Society.

Full particulars of membership may be obtained from the Executive Secretary at the Society's offices at 27/29 South Lambeth Road, London SW8 1SZ Tel: 01-735 3160

Correspondence and manuscripts intended for publication should be addressed to the Editor, 27/29 South Lambeth Road, London SW8 1SZ.

Opinions in signed articles are those of contributors and do not necessarily reflect the views of the Editor or the Council of the British Interplanetary Society, unless such is expressly stated to be the case.

NOTICES OF MEETINGS

Full details on some of the meetings listed below are to be found inside the magazine.

Lecture
Title: **ARTIFICIAL INTELLIGENCE FOR INTERPLANETARY MISSIONS**
by Tim Grant

The first of two lectures by a member of the Daedalus study team on artificial intelligence in space exploration. The second lecture (25 April) considers interstellar missions.

To be held in the Society's Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ on **28 March 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

Lecture
Theme: **EXPLODING STARS**
8y A.T. Lawton
President of the Society

To be held in the Society's Conference Room, 27/29 South Lambeth Rd., London, SW8 1SZ on **4 April 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

One-day Symposium
Theme: **SPACE TRANSPORTATION SYSTEMS**

A one-day symposium on the above theme will be held in the Society's Conference Room on **11 April 1984**, 9.30-5.30p.m.

Offers of papers are invited. Potential authors are requested to contact the Executive Secretary at 27/29 South Lambeth Rd., London, SW8 1SZ.

Lecture
Title: **ARTIFICIAL INTELLIGENCE FOR INTERSTELLAR MISSIONS**
by Tim Grant

The second of two lectures by a member of the Daedalus study team on artificial intelligence in space exploration.

To be held in the Society's Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ on **25 April 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

History Meeting
Theme: **BRITISH ROCKETRY DURING THE SECOND WORLD WAR**

A number of contributions will be presented at a meeting on the above topic, which has been arranged by the Society's History Sub-committee. To be held in the Society's Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ on **2 May 1984**, 6.30-9.00p.m.

(a) G.J. Gollin: " 'Lizzie,' the first 8ritish liquid fuel rocket motor."
(b) B. Earl: "Solid rocket developments in WWII."
(c) E.J. 8ecklake: Guided missiles in WWII."
(d) A series of short films.

Admission is by ticket only. A registration fee of £1.00 is payable, which will also cover the cost of coffee. Members should apply in good time enclosing a stamped addressed envelope.

Lecture
Title: **ASPECTS OF ROCKET TECHNOLOGY**
by Martin Fry
Chairman, *BIS Programme Committee*

To be held in the Society's Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ, on **16 May 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

Lecture
Title: **DISCUSSING SPACELAB**
by Dr. D.J. Shapland
ESA, Directorate of Space Transportation Systems

An overview of the Spacelab 1 mission, by one of our Space '84 speakers, with a short film of the flight.

To be held in the Society's Conference Room, 27/29 South Lambeth Rd., London SW8 1SZ on **30 May 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

LIBRARY

The Library will be open to members from 5.30-7.00 p.m. on the following dates:

28 Mar 1984 — 4 Apr 1984
25 Apr 1984 — 16 May 1984

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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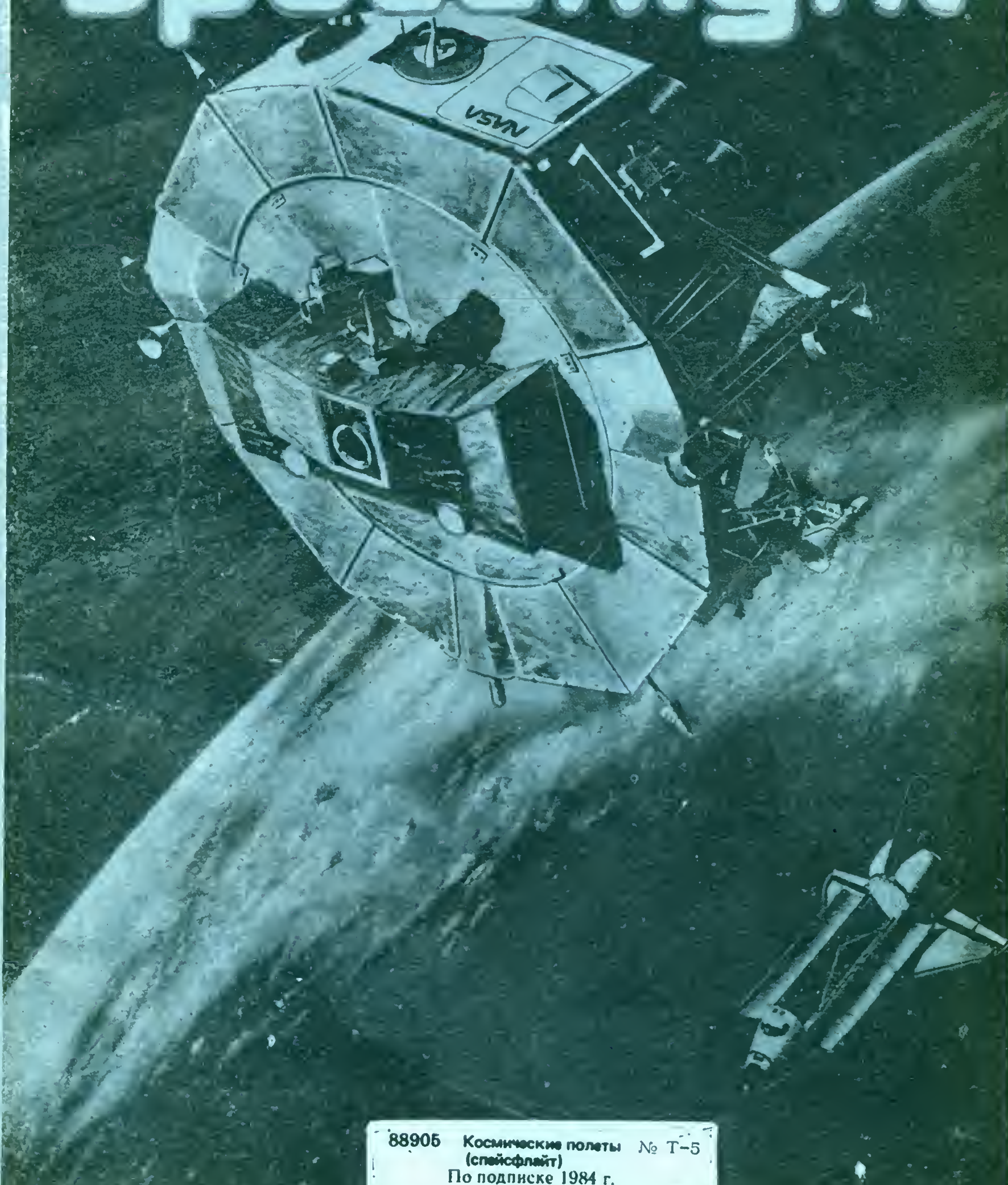

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MAY 1984

BE A PART OF MAN'S JOURNEY INTO THE COSMOS

SPACE '84

16-18 November 1984

SPACE — THE FUTURE OF MANKIND

Our programme for Space '84 at the Brighton Centre introduces a wide variety of space experts covering a wide range of space subjects.

The meeting will be divided into sessions on: New Frontiers, Discovering the Universe, Foothold in Space, Energy and Resources, Advancing Frontiers, the Future of Mankind and Workshop.

The preliminary programme is as follows:

Dr. G. E. Mueller	Space: The Future of Mankind
Dr. W. I. McLaughlin	The Philosophy of Extra-terrestrial Intelligence
Prof. M. Rees	Space Astronomy
Dr. J. K. Davies	New Eyes in Space
D. L. Pivirotto	Space Platforms and Autonomy
I. Bekey	Space Tethers
L. Blonstein	Steps to Space
Dr. D. G. Shapland	Spacelab
Dr. J. T. Houghton	Remote Sensing of the Oceans
C. Honvault	Operational Meteosat
J. Casani	Project Galileo
R. P. Laeser	Deep Space Projects
Dr. A. R. Martin	Space Resources and the Limits to Growth
R. M. Jenkins and D. C. R. Link	Giotto Update
Dr. G. Haskell	Asteroid Probe
R. J. Cesarone	Voyager Beyond the Solar System
S/L R. M. Harding	Space: Human Physical and Mental Adaptability
Dr. R. C. Parkinson	Space Colonisation
A. T. Lawton and P. Wright	Monopoly: Advanced Propulsion for the Future
R. Gibson	European Involvement in Space Station Development
R. J. H. Barnes	to be announced
G. Whitcomb	Missions for ESA's Science Programme

Remember: this is only a preliminary programme and changes will inevitably occur. Further details will be published in *Spaceflight* and *JBIS* as they come to hand.

Civic Reception and Banquet

A Civic Reception (dance/supper) by courtesy of the Brighton Corporation will be held in the Brighton Centre on the Friday evening to give everyone an opportunity to meet before the conference proper begins.

Highlighting Saturday's social activities will be a Banquet with Guest Speakers Sir Peter Masefield and Patrick Moore. The aperitif, 4-course meal and half bottle of wine per person will be provided at a cost of £18.00 per ticket.

To keep the friendly atmosphere of Space '82, the number of places available will be held down to 400. Experience shows that these will soon be snapped up, so early application is essential. Simply fill out the form below and send it to The Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

Yes, please send me a registration form and other details on Space '84. I enclose a 20p stamp.

Name: ....

Address: ....

....

....

spaceflight

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Founded 1933 *Incorporated 1945*

VOL. 26 NO. 5 MAY 1984 *Published 15 April 1984*

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CONTENTS

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WAITING IN THE WINGS

The Society has contended for many years that the UK should take a much more active role in space. Viewed on a long term basis, it is natural that men and women should live and work in space. The cost of such work is beyond the UK budget and can be realised only by cooperating with other nations. The news in 1983 that NASA is prepared to fly a UK astronaut aboard the Space Shuttle is therefore most timely. The opportunity should be grasped with both hands.

In times past the main ambassadors of a country were its explorers and traders. The USSR has recognised this principle: the most prestigious in the Soviet ranks are the cosmonauts. In this vein, the USSR moved ahead of Western nations by offering space accommodation to European and Third World countries. For example, an Indian cosmonaut will fly this year.

The USA has realised the value of these new Ambassadors of Space and is busily giving them as large a world-wide audience as possible. There is no doubt that these people have the ability to sway thousands.

The Society has always advocated human participation in space activities. We presented a Gold Medal to Yuri Gagarin – the first space voyager – before a crowd of many thousands. Alan Shepard, Valentina Tereschkova and all three Apollo 11 astronauts were similarly honoured by the Society. During the Apollo 11 flight our Executive Secretary was asked in Florida when the first UK astronaut would fly. He replied, knowing only too well the way these things work, "seventy-third – after Ghana!"

Now the Europeans are not far behind, with German, French, Dutch and Swiss astronauts. Claude Nicollier, now training as a NASA Mission Specialist, is a Society Fellow. It appears that countries even as small, in space terms, as Brazil and Australia will have the opportunity of flying astronauts aboard the Space Shuttle. No less than six Canadians will train to astronaut level; Japan and West Germany are investing in complete Spacelab missions, with their own countrymen travelling into space. It is reported that the Soviet Union may offer places aboard one of their Soyuz craft to countries such as Sweden.

It is inconceivable that a nation with our scientific heritage should be one of the last into space. The Society has always maintained that a vigorous UK space programme is essential; we now have the opportunity, at minimal cost, to establish a high profile.

We cannot afford to miss out yet again.

COVER

While the Space Shuttle is designed for use in low Earth orbit, most satellites operate at higher altitudes. NASA has therefore asked aerospace companies for their proposals for an Orbital Manoeuvring Vehicle, a reusable stage that could release, capture or inspect satellites in orbits up to 3,700 km. The 5 m-diameter concept shown here is from Boeing; NASA is expected to select at least three proposals in the coming months for further studies.

Boeing Aerospace

В журнале не печатается ряд страниц.

UK Space Policy

Sir, With the present fragmentation of space interests in government departments, space technology is a Cinderella which, at the tail-end of every priority list, gets the worst deal in almost every case. It is no use expecting that this situation is relieved by the fact that the present Prime Minister was originally qualified in chemical technology. That is hardly relevant in the present situation where the order of the day is to cut public spending. The manner in which such cuts are made is in the hands of civil service bureaucrats who have no particular regard as to how this is done. A consequence is that many research and development areas are being savaged to a greater extent now than at any time in previous years. With the existing set-up, I can only see governmental support of space activity coming out badly.

If there were a single agency dealing with all aspects of space technology it would still be vulnerable to cuts, but a least these would be proportional and related to corresponding economies in other governmental departments: This has never been the case in the past when, for example, a cut of 10% in aerospace research and development could imply a complete withdrawal of funds in a large part of the space activity – the demise of UK participation in space vehicle development was a case in point.

Unfortunately, we still have the same institutional arrangements in governmental sponsorship of space technology, so there is little possibility, in my opinion, that we shall see any new initiatives taken in the immediate future in any particular space enterprise. If there is any sympathy towards astronautics in governmental circles, then the most we might hope to achieve would be to try to persuade them to take the step towards setting up a single authority co-ordinating a space programme.

Today, thanks to our own efforts, the BIS is economically stronger and more active than ever. Our standing outside the country is good – particularly with NASA. This is a gratifying testimonial to our Society's pioneering work in advancing astronautics. However, our influence in establishment circles in this country is certainly far less than we had 20 years ago during the era of the Macmillan Government. We have little, if any, voice owing to lack of 'media' interest – I even wonder if the spokesmen for space on TV are concerned with furthering their own careers rather than their country's interests in the field.

A main concern of BIS Space Policy must be with rectifying this situation and, at least, restoring and then augmenting our position in these spheres.

DR. L.R. SHEPHERD
BIS

Advance or Retreat?

Sir, Without exception all the speeches at the Society's 50th Anniversary banquets looked forward to the many new and exciting possibilities now opening out in space, using a Space Station as the major stepping stone.

We have yet to see what course will be adopted in the UK. Although we have a present preoccupation with more pressing concerns it seems inconceivable that a leading technical country such as ours should do other than participate to the fullest possible extent. We must not 'Wait in the Wings' now that we have been offered a part on the centre stage.

For the first time in decades the UK has a Prime Minister with the knowledge and flair needed for handling technological matters. If the American initiative can be made to reach the stage of informed discussion at Cabinet level the outcome would be assured. The main danger is that such a bold stroke will be diverted and watered down by government minions in between, perhaps with little knowledge of (an even less enthusiasm for) space matters – or who feel that other items are more urgent.

This latter is, of course, the rock which has wrecked so many previous UK space initiatives. Where a space concept could not be headed off directly it was diffused and diluted by distracting elements offered to either industry or the scientific branches. Dilution followed the well known Parkinson's Law corollary that "The number of Admirals increases as the size of the Navy is reduced."

The UK proliferation of Space Directorates has beautifully supported this but has sadly ensured that the ensuing competition prevents any attempt to speak with one coherent and authoritative voice.

Many years ago our Society argued the case to the UK Government that a single independent space agency should be set up and – of prime necessity – staffed and run by people wholly dedicated to and responsible for space developments. All this had to be without the deadweight and overheads of directors, chairmen and a clutch of committees simply interested in promoting their own existence and thereby dragging their feet.

The computer revolution has been nationally recognised and nurtured by the Ministry of Information Technology, with benefits to education, commerce and industry. The space revolution is now happening too.

More than ever we now have a major need to present the case to the decision makers themselves. Experience indicates that less active moves will fail – and the UK will once again slide into the technological background watched by embarrassed or delighted smiles of more technically alert and politically discerning overseas colleagues.

Part of the Space Stage Centre has been offered. The UK must now step into the spotlight and follow up the offer in a competent and efficient manner. If ever there was a need for the UK to have a national space organisation, it is now.

P. FRESHWATER
Henley-on-Thames, Oxon

Into the Solar System

Sir, I know that the Americans are planning to launch their Galileo craft to Jupiter in 1986, but what other planetary and deep space missions are firmly planned for the years ahead?

RAY SWEETMAN
London

Reply:

There are many Solar System missions under study but only a few are actually firmly planned. The Galileo Jupiter orbiter/atmospheric probe will be launched by Shuttle/Centaur in May 1986 for arrival at the giant planet on 25 August 1988. The probe will have separated 15 days before encounter, in March 1988. At about the same time as Galileo, another Shuttle/Centaur will launch the European Solar Polar Mission towards Jupiter. It will arrive there in mid-1987, swing over the planet and head down

to 70° south of the ecliptic plane towards the Sun. This mission — the first to take measurements so far away from the plane of the planets' orbits — should have included a second, American, probe flying on the opposite side of the ecliptic but it was cancelled.

Funds for a Mars geophysical orbiter have been allocated in NASA's FY 1985 budget. The plan is to launch the probe in August 1990 to arrive at Mars a year later to observe the planet for a full year (about two Earth years).

Halley's Comet will be greeted by no less than four probes just after perihelion in February 1986. ESA's Giotto will be launched on 10 July 1985 for an encounter on 13/14 March 1986, and Japan's Planet-A will leave Earth on 14 August 1985 for its closest approach of 100,000 km on 8 March 1986. The first launches, though, will be Soviet. Two craft will leave next December (15th and 21st), deposit two landing probes on Venus the following June, and then head on to meet the comet on 6 and 9 March 1986.

Venus will receive another visitor in July 1988. The US Venus Radar Mapper (VRM) mission will be launched the previous April to map most of the Venusian surface for 243 days at a resolution of 1 km.

The Soviets have also said they are planning to rendezvous with the Martian moon Phobos following a 1986 departure. A lunar polar orbiter with French participation might materialise between 1987 and 1990.

Some scientists are pressing for the backup hardware for Galileo-Jupiter to be launched as Galileo-Saturn in January 1987. The Earth would be encountered in April 1990 to provide the energy for an arrival at Saturn in 1995. The atmospheric probe could be used either for the planet or Titan, the large moon with an extensive atmosphere.

Shuttle Manoeuvring

Sir, I found the account of the STS-6 mission very interesting in the January issue. During this mission, as in others, several minor engine burns were made in a simulated rendezvous manoeuvre. Obviously the commander and pilot would be in their seats in the cockpit at the time, but what about the other crew members? For example, on the fourth event of this kind on STS-6 Musgrave and Peterson were tending to their EVA suits while Weitz and Bobko supervised the burn. Did Musgrave and Peterson just carry on with what they were doing, as they would have done if the RCS thrusters were firing simply to maintain or change attitude? Did Weitz warn them, giving them the chance to brace themselves against a convenient wall while the engines were on? Or did they have to stop what they were doing altogether and go to their seats on the flight deck until it was over?

STEPHEN ASHWORTH
Oxford

John Pfannerstill, writer of our Shuttle mission reports, replies:

Back in the Apollo days, when we had a 29,000 kg Command and Service Module propelled by the mighty 9,300 kgf Service Propulsion System, all crewmen were confined to their couches during engine burns. However, this is not necessary on the Shuttle. The Orbiter has a "dry" weight of about 68,000 kg which is quite a bit of mass to be pushed around by even the 5,500 kgf combined thrust of the OMS. Thus, the acceleration is very low - far below what would be required for the crewmen to strap into their seats. In fact, once orbit is established, the mission specialist seats are folded up and stowed away until entry, so there would have been no seats for Musgrave and Peterson to strap into in any event.

I looked back over my transcript of the STS-6 air-to-ground communications to see if there was anything to indicate that Weitz warned the crew about the burn Mr. Ashworth mentions but I cannot find anything conclusive.

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

An Australian Satellite

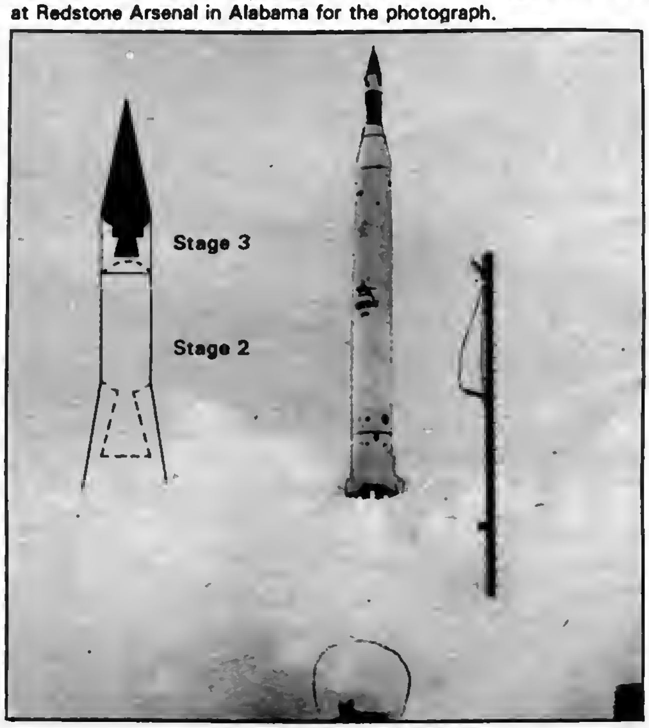
Sir, There seems to be a great mystery surrounding the 'Sparta' launch vehicle which orbited the Australian Wresat-1 satellite on 29 November 1967 from Woomera. First stage was a Redstone, but what were the solid upper stages? 1967 seems much too late for it to have been a Juno 1 vehicle.

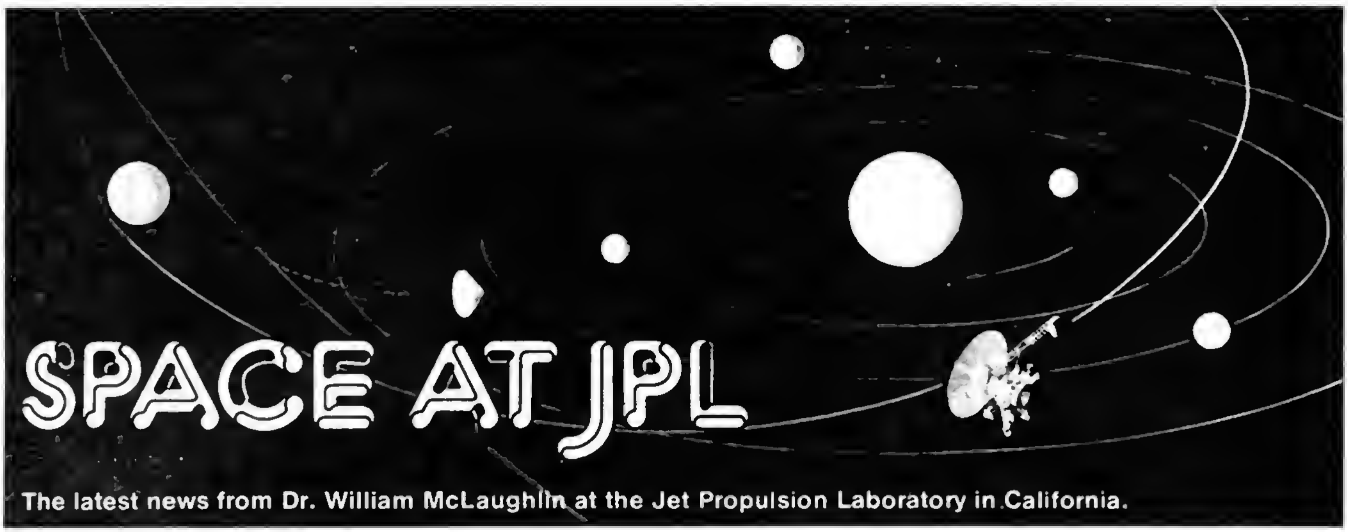
JOHN PITFIELD
Dorset

Reply:

WRESAT was a 45 kg satellite launched into a 171 x 1250 km polar orbit to study solar radiation; it survived for five days. The orbit and mass show that the rocket was not a Juno 1 (used to launch the first US satellite) because they were beyond the capabilities of such a vehicle. As far as we can tell, it was a 'one-off' rocket for just this task, but information is scarce. The second and third stages — clearly differing from those of the Juno 1 — were produced by the LTV company, so they could have been connected with the US Scout satellite launcher. Space historian Mitchell Sharpe has pointed out to us that it was *not* a Sparta rocket — that was a military project involving the Weapons Research Establishment in Australia and the US Army Research Projects Agency. *A.W.*

Launch of WRESAT-1 in 1967. The third stage remained attached to the satellite, which was about 160 cm long. The satellite's outer surface formed the conical rocket nose; a detachable nose cap was carried. Our thanks to Ralph Perrill of the US Army Missile Command at Redstone Arsenal in Alabama for the photograph.





RENDEZVOUS WITH KOPFF

The first of the missions proposed for the Mariner Mark II (MMII) series is the 'Comet Rendezvous with Asteroid Flyby' (CRAF). It was recently announced that Comet Kopff has been selected. CRAF would differ from ESA's Giotto mision to Comet Halley primarily in that it would rendezvous with its target for many months, while Giotto and the other Halley missions will conduct fast flybys. For the maximum scientific return, two asteroids will be flown past on the way.

Kopff was discovered in 1906 and has been observed for 12 of its 13 returns to perihelion (the point in its orbit closest to the Sun); the 1912 apparition was missed. Its last perihelion passage was in August 1983, when visual observers noted brightness flaring while one-magnitude variations in the infrared were also observed from night to night. In other words, Kopff should be an active and interesting object for study.

After launch in July 1990, the spacecraft will head for its first asteroid target: a candidate is Namaqua (approximate 14 km diameter) which would be encountered 225 days after launch. The second asteroid might be Lucia (approximate 84 km diameter) visited 365 days after launch. Then, four years after launch, MMII would reach Kopff, two years before perihelion.

After a reconnaissance approach, Mariner would establish an orbit about the nucleus. The weak gravitational force of the nucleus, which may be about 3 km in diameter, would mean a 4 to 12 day orbit at a range of 15 to 30 km. It might be necessary to supplement traditional optical and radio navigation with a radar altimeter for accurate navigation at such close range.

From this vantage point, before the comet has moved close enough to the Sun to become active, the nucleus can be studied in detail with the camera and other instruments. For the first time the mystery of the nucleus will be unveiled, revealing the shape, texture and dynamics of that small kernel.

As Kopff approaches the Sun and grows more active, producing dust and gas, Mariner will be moved away for safety but will still be flying in formation. The distance from the nucleus will be varied in order to sample the dust in different locations.

The MMII for this mission will have a mass of about 1000 kg (dry) and 2450 kg (with fuel). The required power is about 440 W, supplied by a combination of Radioisotope Thermoelectric Generators and solar panels. The scientific payload has not been selected but, in addition to wide-angle and narrow-angle cameras, it may contain an IR reflectance spectral mapper, magnetometer, gamma and X-ray spectrometers, dust detector and analysers, neutral and ion mass spectrometers, and a plasma wave receiver. The highest data rate is a surprisingly low 9.2 kilobits/s.

The second proposed MMII mission is a Saturn Flyby/Titan probe; rendezvous with a main belt asteroid is suggested for the third mission. The project manager for Mariner Mark II is Ronald Draper of JPL with NASA sponsorship from the Office of Space Science and Applications.

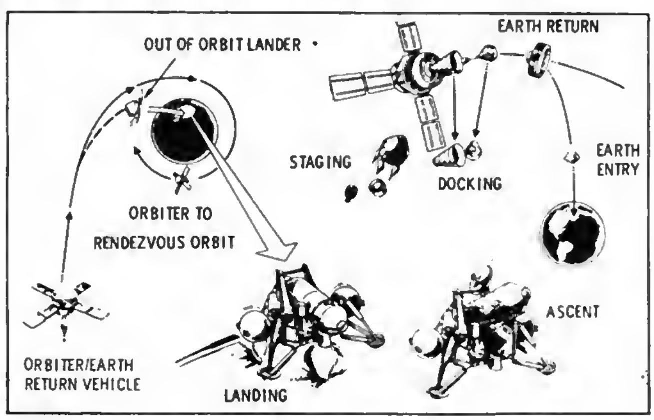
ADVANCED PLANNING

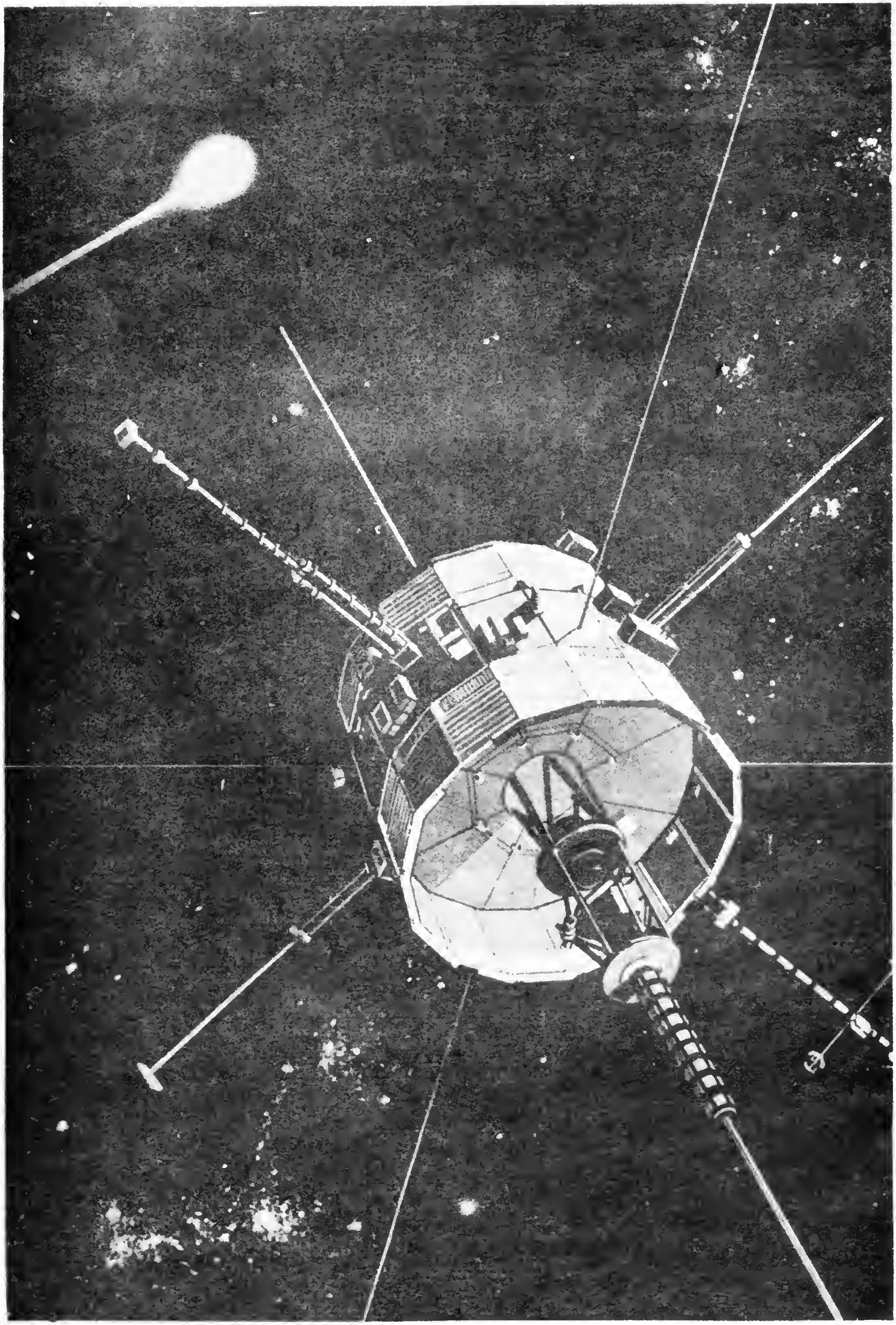
Since the April 1983 issue, it has been customary to devote a section to an advanced concept. This month, the results of a planning 'process' will be reviewed.

The 22nd. annual Aerospace Sciences Meeting of the American Institute of Aeronautics and Astronautics (AIAA) was held in Nevada in January and contained a session on "Planetary Exploration Through the Year 2000." The session was chaired by JPL's Chief Scientist, Dr. Arden Albee, and looked at a proposed planetary programme for NASA for the remainder of the century. Four aspects emerged:

1. Ongoing projects, incuding Voyager, Galileo, the Pioneer series, and the Venus Radar Mapper (VRM).

An older proposal for a Mars Sample Return mission; this includes rendezvous and docking in Mars orbit before return to Earth.





2. The Mariner Mark II Program (MMII) for exploration of the outer Solar System, comets and asteroids. MMII is one portion of a "core programme," the second being,
3. The Planetary Observer Programme for exploration of the inner Solar System using converted Earth satellites.
4. An "Augmented Programme" on top of the Core. Unlike the Core Programme, it would feature technologically challenging missions.

The Augmented Programme features the most advanced concepts. The Core idea was formulated by NASA's Solar System Exploration Committee, as described in the September-October 1983 issue.

Carrying out the two schemes depends on the appropriate NASA, presidential and congressional approval, but, with respect to planning, their outlines are becoming clear. Dr. Geoffrey Briggs, Director of the Solar System Exploration Division within NASA's Office of Space Science and Applications, sees the primary objective of an Augmented Programme as the return of samples to Earth from planetary and primitive Solar System bodies (comets, asteroids). It "takes advantage of sophisticated techniques available in Earth laboratories," according to Briggs.

Preliminary thoughts on a Mars Sample Return (MSR) mission foresee a launch from the proposed Space Station with a high-energy Centaur vehicle and a return from Mars to the Space Station using the Earth's atmosphere as a brake. One scenario has a launch in 1996 with a return to Earth in 1999 after one year of operations on the Martian surface by a planetary rover roaming hundreds of kilometres in its search for samples. A second mission would follow, with its rover operations continuing into the next century. Other features would be a direct return to the Space Station without rendezvous in Mars orbit and a communications satellite for high data-rate return.

Dr. David Morrison of the University of Hawaii, and a former chairman of the SSEC, also foresaw the Augmented Programme encompassing a comet sample-return mission, lunar exploration options, and sophisticated investigations of the outer Solar System.

While none of the missions addressed has been approved there was a degree of optimism that was noticeably absent from the planetary community prior to the cycle of SSEC planning which began about three years ago.

MGCO IN NASA BUDGET

The Mars Geoscience/Climatology Orbiter (MGCO) appeared in the Fiscal Year 1985 budget plan of NASA as detailed in the President's 1 February budget message. A total of $16 million was allocated for it during FY85. MGCO is the first mission in the Planetary Observer series and may be launched as early as 1990 to explore Mars from polar orbit (see the December "Space at JPL").

Also in the plan for FY85 were $92.5 million for continuing work on the Venus Radar Mapper, $56.1 million for Galileo development, and $9 million for the ongoing International Solar Polar Mission. The amount allocated for Planetary Exploration was $286.9 million out of a NASA total of $7,491.4 million. Of course, these budget proposals still must be approved by the Congress.

Facing page: Goddard's ICE mission (formerly ISEE-3) to Comet Giacobini-Zinner is being tracked by the 64 m antennae of JPL's Deep Space Network.

TRACKING ICE

International Sun Earth Explorer 3 (ISEE-3) has been renamed 'International Cometary Explorer' (ICE) as it speeds on its way to encounter Comet Giacobini-Zinner in September 1985. This Goddard Space Flight Center craft was launched in 1978 and is being tracked by JPL's Deep Space Network (DSN).

It originally measured the flow of particles between the Sun and Earth. Large propellant reserves and lunar gravity assists are taking it towards the comet to fly through the tail (see the March 1983 issue). The instruments will not provide pictures, but this first comet mission will make fields and particle measurements during its passage through the tail. Included is a magnetometer (Principle Investigator is Dr. Edward Smith of JPL) to look at the magnetic fields.

Since ICE will work far beyond its designed distance from Earth, the large 64 m antennae of the DSN will be used. For the last few years Goddard and JPL have been working to transfer tracking smoothly to the DSN as ICE moves further away. The transfer actually took place on 4 January.

After its Giacobini-Zinner mission is completed, ICE will be used in the internationally-based exploration of Comet Halley by taking measurements of the solar wind upstream of Halley before and after perihelion.

GALILEO NOTES

The Galileo Orbiter and Probe will be launched for a Jupiter mission in 1986. The International Solar Polar Mission (ISPM; see the March 1983 issue) is also scheduled for a 1986 launch for solar exploration. However, ISPM will fly past Jupiter to send it to a solar encounter. Two Shuttle-launched missions will thus use the "Jupiter window" (launch period) in 1986 and NASA must carefully plan launch operations. Shuttle/Centaur 'match-mate' tests have now been scheduled at the Kennedy Space Center from January to May 1986. The ISPM period opens on 15 May, while that of Galileo opens on 20 May. There is no margin for error - hence the thorough testing period at KSC.

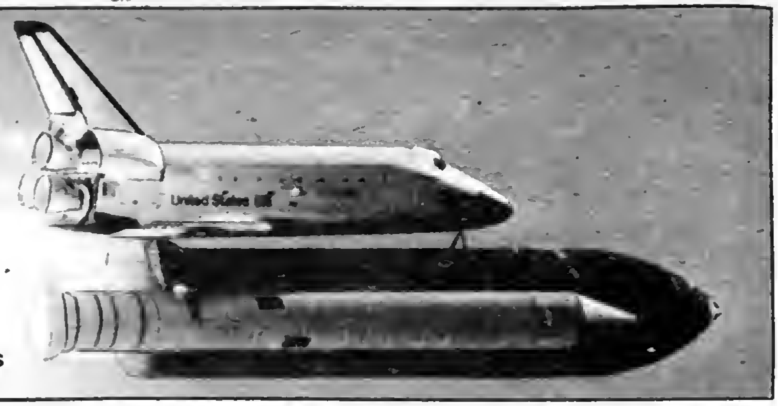
The Galileo Orbiter's electronics will use some 21 microprocessors and 3500 memory chips. The random access memory chip on Galileo will carry 16,384 bits of information and contains over 100,000 transistors. This and other chips, however, must be protected against the harsh Jovian radiation. For such protection, the Galileo project is using the Sandia National Laboratories in New Mexico. Sandia has had extensive experience with developing radiation-hardened microelectronics and is designing the Galileo chips to withstand 150,000 rad (a chest X-ray dose is about 0.025 rad, while a whole-body dose of about 1000 rad is usually fatal to humans). Sandia's work, which began in August 1983, should lead to the delivery of the hardened parts next September.

Jupiter's rings are probably entirely made of dust particles without the larger-sized particles as are found in the Saturnian rings. Galileo's Orbiter will carry a dust detection experiment to measure the sizes, spread and paths of the particles; it will be able to detect as many as 100 impacts per second. The Principle Investigator is Eberhard Grun of the Max Planck Institut für Kernphysik in Heidelberg, West Germany.

The manager of Project Galileo, John Casani of JPL, will be a speaker at the Society's Space '84 'weekend' at Brighton in November.

SPACE REPORT

A monthly review of space news and events



SATELLITES

CHEAPER WEATHER SATELLITES?

The US space and weather agencies are studying the possibility of putting sensors aboard commercial communications satellites (destined for geostationary orbit, 36,000 km high) instead of flying "purely" weather satellites. The simpler proposal is to rent space to carry new equipment for testing in orbit; adding a full operational weather satellite payload might prove to be too complex.

Ford Aerospace built the Indian Insat – launched by Shuttle mission 8 last September – as a combined geostationary weather/communications satellite.

ERS TESTING

Europe's first pre-operational remote sensing satellite, ERS 1, will be devoted mainly to monitoring ice, coasts and ocean areas. Among the instruments is an active microwave package combining the functions of a Synthetic Aperture Radar (SAR) and wave and wind scatterometers. The aim is to measure winds and waves and to take all-weather high resolution images of coastal zones, oceans, ice areas and (on an experimental basis) land regions. Four countries (Germany, the Netherlands, France and Canada) have each built a C-band scatterometer to find the best type for flight aboard ERS in 1987. Each was flown aboard an aircraft in February over the North Sea, in conjunction with a German platform supplying "sea truth" data, and about 40 km off the Brittany coast in conjunction with a French oceanographic vessel. The data are now being compared.

HIPPARCOS DETECTORS

Hipparcos, the European satellite designed to measure the exact positions of 400,000 stars, will be carrying £100,000's worth of UK photomultipliers acting as light detectors when it is launched by an Ariane rocket in March 1988.

The tubes will be supplied by Thorn EMI to the Laboratory of Space Research in the Netherlands for inclusion in the detector package; the satellite itself will be completed in France.

It was proposed in 1967 that a satellite devoted to astrometry should be flown. Although in 1970 rejected by the French space agency, CNES, for cost reasons the project was eventually proposed to ESRO's scientific body and from there it was finally adopted by the European Space Agency in 1980.

ESA defined the mission of the astrometry satellite as the determination of the trigonometric parallaxes, proper motions and positions of several hundred thousand stars, most of them brighter than magnitude 10. The data will be used to construct an accurate, coherent, stellar reference frame with many fundamental uses for astronomers.

WEATHER SATELLITE FAILS

The Japanese GMS-2 weather satellite successfully transmitted pictures of the Earth eight times a day from August 1981 until last November, orbiting in its geostationary orbit at 140°E longitude. The optical system scanned the Earth *via* a mirror moved by an electric motor, with the mirror returning to its starting position within 150 s of completion. Problems arose when the motor began to slow down, and by 12 January the delay had crept up to almost four hours.

Japan's weather agency therefore decided to shift the old GMS-1 satellite from its reserve slot at 160°E to 145°E in order to take over the work. Ground controllers are hoping they can preserve the dwindling supply of attitude control fuel until GMS-3 can be launched in August. If not ,weather information to about 20 countries will be affected.

SPACE SHUTTLE

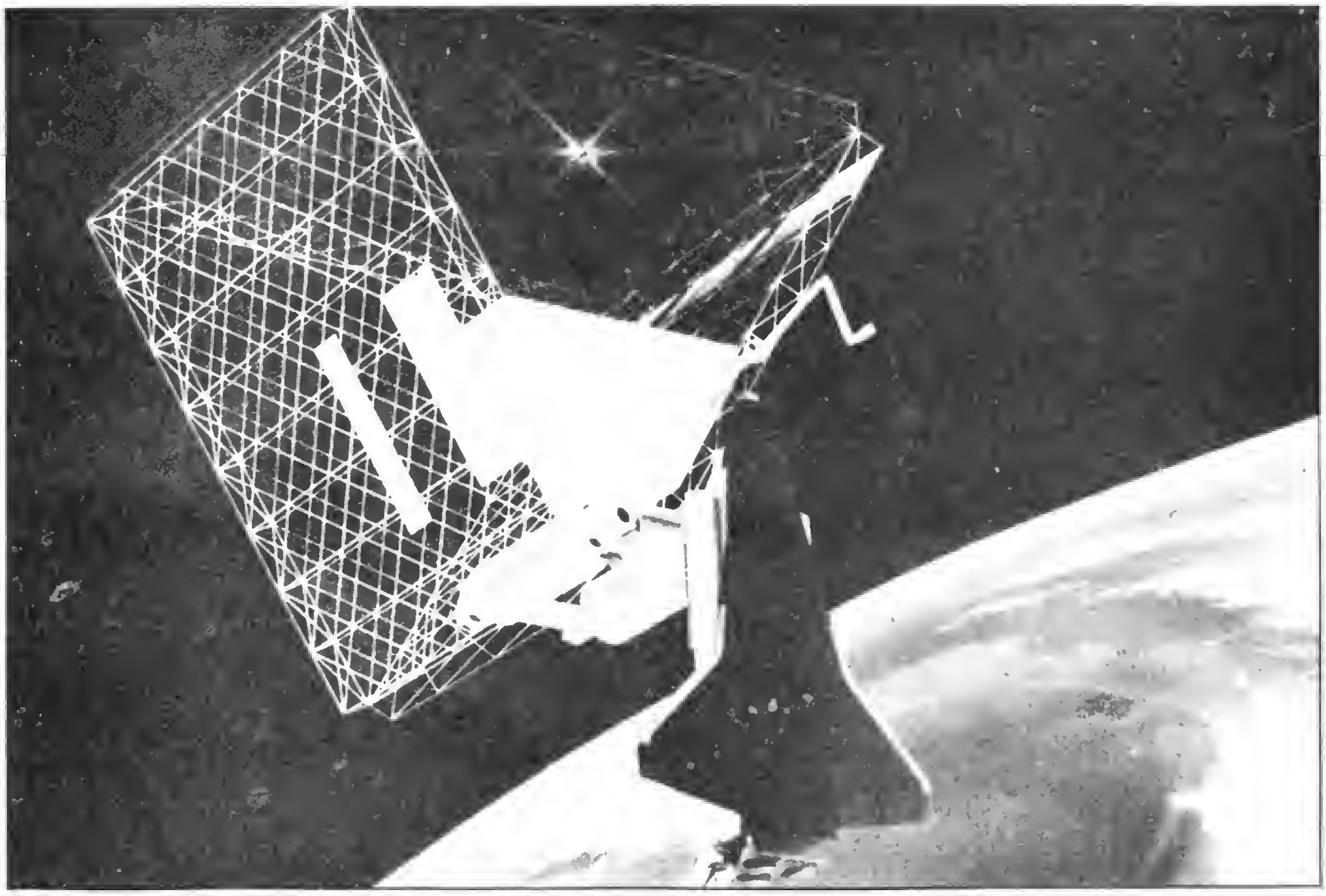
MORE SHUTTLE CREWS

The Long Duration Experiment Facility released by the Mission 41C crew this month will be retrieved from orbit next February during flight 51D. The six day trip of *Challenger*, on its ninth orbital journey, will be commanded by Brewster Shaw on *his* second Shuttle assignment - he flew under John Young last December on Spacelab 1.

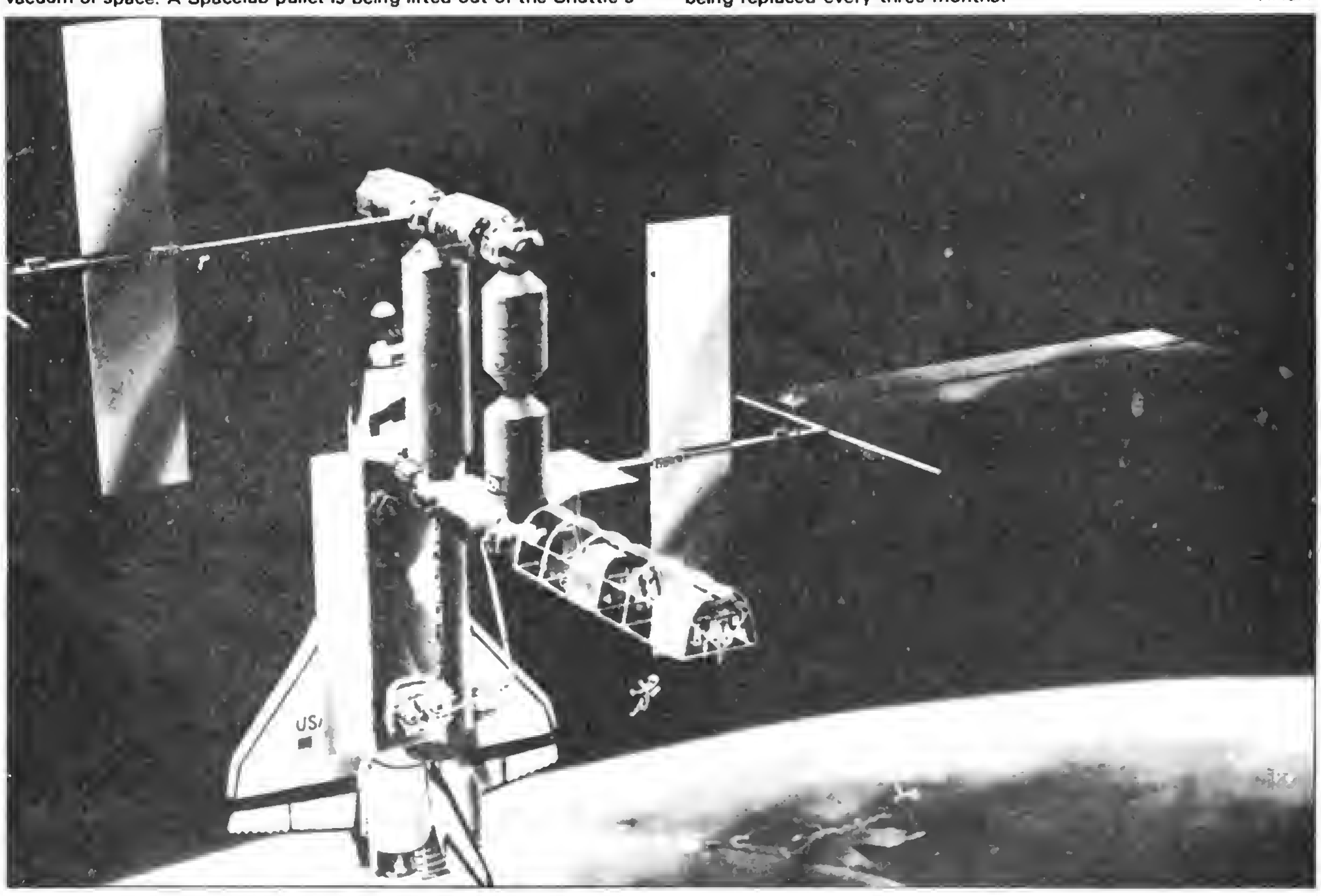
Shaw's crew are all Group 9 NASA astronauts, accepted into the ranks in 1981 and only now being assigned to missions. Bryan O'Connor is the pilot, while the three mission specialists are Sherwood Spring, Jerry Ross and Mary Cleave.

Mission 51D will also release the Syncom 4-3 commercial communications satellite.

Spacelab 4 in January 1986 - 61D for the Shuttle - will concentrate on life sciences experiments following *Columbia's* ninth launch. Only the three mission specialist astronauts have been announced, leaving the two pilots and two payload specialists still to come. This is because the MS astronauts require much lengthier specialised training - the pilots can train for general missions and a group of four scientists are already working for the two



Although there is no design yet for a permanent US space station, approved by President Reagan in January, NASA have issued several artist's concepts. The version above is based on a triangular framework upon which solar cells could be mounted to provide power. The Spacelab-type modules provide facilities for the crews. The concept below includes an open structure for mounting experiments in the vacuum of space. A Spacelab pallet is being lifted out of the Shuttle's cargo bay to join the others in the experiment rack. President Reagan said that European, Canadian and Japanese involvement would be actively sought; NASA Administrator James Beggs has the task of persuading other nations that cooperation would be in their interest. Present plans call for the station to be in a 28.5° inclination, 450 km high orbit, permanently manned, with the crews of 6-8 astronauts being replaced every three months. *NASA*



The crew of Shuttle mission 41C (previously STS-13) should, as this issue reaches members, have completed one of the most dramatic flights yet: capturing a satellite, repairing it, and sending it back into orbit. The SMM (Solar Maximum Mission) satellite, a solar observatory, should now be able to begin work again. From left, the crew is: Commander Bob Crippen, mission specialists Terry Hart, James van Hoften and George Nelson, and pilot Dick Scobee. Crippen flew the first and seventh Shuttle missions but his crew are all new to space. Hart worked in electronics with Bell Industries for 10 years before his selection in 1978; van Hoften is a former US Navy pilot with several engineering degrees and Nelson was an astronomer before acceptance by NASA. Dick Scobee was a USAF pilot until 1980, having flown in Vietnam, and has worked on the X-24B lifting body and Boeing 747 projects.

Concerning a later flight, mission 41E - the old STS-15 - has now been cancelled because the Inertial Upper Stage will not be ready in time for a 14 July launch. More details in next month's 'Space Report.'

Information: D.J. Shayler

PS positions. This last group consists of Dr. Millie Fulford, Francis Gaffney, Robert Phillips and Bill Williams.

The three mission specialists are James Fabian, Rhea Seddon and John Fabian. Seddon will fly first this August, on 41F, and Fabian will go aloft in 51A this October, following his STS-7 mission last June.

CANADIAN ASTRONAUT

A Canadian will fly as a payload specialist astronaut on Shuttle mission 51A in October, NASA announced in early February. The names of the Canadian and his backup will be announced in March. Selection will be made by the National Research Council of Canada from a team of six chosen on 5 December last year (two more will fly in 1985 and 1986).

Mission 51A will be a six-day flight, carrying Telesat Canada's Anik C-1 satellite and a Getaway Special experiment designed by two Canadian high school students.

SHUTTLE TELEPHONE

The success of the American 'Shuttle telephone' services has been evidenced by the hundreds of thousands of calls made. Space enthusiasts all over the world have been able to call in and hear live transmissions from the Shuttle and Mission Control in Houston. The 41B mission in February (formerly STS-11) was more accessible to UK members: British Telecom offered its own service, charging £1.62 for three minutes of eavesdropping.

SPACE VEHICLES

MORE CENTAURS

When the Milstar military communications satellites are orbited towards the end of this decade they will use the Shuttle/Centaur G combination, it has been decided. The US Air Force planned originally to use the Inertial Upper Stage, but the Centaur capability to geostationary orbit - 4500 kg - is proving attractive.

The new enlarged Centaurs (4.26 in diamater; the present versions are 3 m wide) will fly with the Shuttle on such missions as Galileo-Jupiter and the Solar Polar Mission, as well as for military applications. See last month's 'Space Report' for further details on the new Atlas/Centaur models.

SPACE PROBES

SOVIET HALLEY PROBES

The two Soviet probes destined for Halley's comet - Vega 1 and 2 - were reported in early February to have begun assembly at the Space Research Institute of the Soviet Academy of Sciences.

The craft will be launched this December, fly past

Venus in June next year (releasing landing vehicles) and then proceed to Halley encounter in March 1986. Since they are not designed to withstand the high-speed dust thought to surround the comet, they will approach no closer than 10,000 km. TV cameras are expected to provide resolution of 180 m - Europe's Giotto probe should provide images a factor of four better.

ASTRONOMY

PECULIAR IRAS COMET

Comet Hartley-IRAS 1983, one of the six comets discovered by the Infrared Astronomical Satellite (IRAS, which ended operations last November), has turned out to be a very interesting object. Its 22-year period orbit is inclined to that of the planets - the ecliptic plane - by 96°, making it the only retrograde comet with a period of less than several centuries. How it got into such a path is a mystery.

COMMUNICATIONS

JAPANESE DIRECT TV

The BS-1A Japanese direct TV broadcast satellite was launched by an N2 rocket from the Tanegashima site on 23 January to provide two colour TV channels to remote and built-up urban areas. Yuri-2A (Lily-2A) is now parked in geostationary orbit at 110°E longitude; it will be joined by BS-2B in August to provide backup services.

RAINBOW SATELLITES

RCA are to design and build a domestic communications satellites system for Rainbow Satellite Inc. of California.

The initial contract calls for two high-powered Ku-band satellites, telemetry tracking and control equipment, launch services and operator training. There is also the possibility of more satellites in the future. The first will be launched in 1986 by either a Shuttle or a European Ariane; life expectancy is 10 years.

Each satellite will have 24 channels operating in the 14/12 GHz band, using 40 watt travelling wave tube amplifiers for coverage of the 48 American states. The system is being designed for video, voice and data services to provide high-quality signals for SMATV (Satellite Master Antenna Television) and the common carrier operations.

The satellite will feature deployable antennae for efficient beam shaping to cover the continental US and provide spot coverage for the east and west coasts.

NASA PROJECT DROPPED

NASA's plans to launch an experimental communications satellite operating in the 20/30 GHz bands have been dropped because Hughes Aircraft Co. have announced their intention of flying such a satellite using their own money.

The "Advanced Communications Technology Satellite" programme was to have investigated the use of the new frequencies in an effort to alleviate congestion in the presently-used bands. The use of private financing will save NASA some $100 million, though Hughes' project will not be a extensive.

An artist's impression of the Galileo probe (due for launch in May 1986) as it plunges into Jupiter's atmosphere. The heatshield has just separated and the parachute has emerged to slow the descent.
NASA

OTHER NEWS

SATELLITE WEAPON

The first flight test of a US anti-satellite missile from an F-15 aircraft was carried out on 21 January over California. This initial test was used to study the effect of the weapon leaving the aircraft – it carried no warhead and did not travel into space.

Several attempts were made in the late 1950's and early 1960's to put small satellites into orbit from an F-4, but the sudden shift in the aircraft's centre of gravity with launch caused severe handling problems.

MILESTONES

January 1984

29 The 14th. Chinese satellite is inserted into a 359 x 6479 km orbit. It is possibly a failed test of a geosynchronous communications satellite system.

February 1984

2 NASA announces the crews of two further Shuttle missions. Mission 51D in February 1985 will be commanded by Brewster Shaw, with Bryan O'Connor, Mary Cleave, Sherwood Spring and Jerry Ross. The Spacelab 4 flight in January 1986 will carry James Bagian, John Fabian and Rhea Seddon. The commander and another crew member will be selected later. See 'Space Report' for further details.

2 A Canadian astronaut will fly on Shuttle mission 51A in October, NASA announces. Two more will fly in 1985 and 1986.

8 Cosmonauts Leonid Kizim, Vladimir Solovyov and Oleg Atkov are launched aboard Soyuz T–10 at 15.07 Moscow Time to dock with Salyut 7. At a pre-flight press conference it was suggested a long mission was in prospect. Kizim commanded Soyuz T–3 in 1980; he and Solovyov were backups to the Soviet-French crew in 1982. Atkov is a physician. Georgi Beregevoi, head of the cosmonauts' training centre said that "The development of permanent orbital complexes with rotating crews is the main [objective] of Soviet cosmonautics."

9 The Galileo Jupiter atmospheric probe passes its final review at the manufacturers before shipment to JPL in California. The probe and orbiter will be launched in May 1986 to arrive at Jupiter in August 1988.

15 NASA Administrator James Beggs announces that the Johnson Space Center in Houston will have responsibility for the Space Station project.

16 The Ariane L8 launch, with the Intelsat 5 F8 communications satellite, is set for 5 March, between 00.50 and 02.41 GMT from Kourou in S. America.

17 The area around Shuttle *Challenger* has to be cleared when poisonous nitrogen tetroxide leaks during servicing. It happens again on the 20th.

March 1984

1 A Delta rocket from California orbits the Landsat 5 and UOSAT 2 satellites.

3 Shuttle Mission 41D (previously STS–14) will be delayed at least two weeks beyond the 4 June target date because the left OMS pod has been removed from *Discovery* for use on *Challenger* during mission 41C in April.

5 Ariane L8 successfully launches the Intelsat 5 F–8 communications satellite from Kourou in S. America at 00.50 GMT into an initial 186.5 x 36,045 km orbit.

5 NASA Administrator James Beggs visits London to discuss UK involvement in the US Space Station with government officials.

DO YOU KNOW?

The picture below shows two happy people. Who are they? Answer below the photograph.

Novosti

They are Valentina Tereshkova and Valeri Bykovsky. Bykovsky was launched aboard Vostok 5 on 14 June 1963 for an 81 orbit mission, during which he was joined by the first space woman aboard her own craft. She remained aloft for almost three days and remained the only female spacefarer until Svetlana Savitskaya flew in 1982. Owing to his first name Bykovsky is occasionally credited with being the first woman in space!

DO YOU REMEMBER?

25 Years Ago...

1 May 1959. NASA announces that the Beltsville Space Center which came into existence on 15 January 1959 is to be renamed the Goddard Space Flight Center in memory of Dr. Robert H. Goddard who flew the first liquid propellant rocket in 1926.

20 Years Ago...

24 April 1964. NASA's Manned Spacecraft Center recommended that a forward docking port on the Grumman-built Apollo lunar module be eliminated and that a rectangular window be placed in the roof of the LM crew cabin to enable the top docking port to be used during link-up with the Apollo command module following return from the lunar surface.

15 Years Ago...

17 April 1969. The NASA/USAF X–24A lifting body makes its first glide flight with Major Jerald R. Gentry at the controls.

10 Years Ago...

19 April 1974. Ames Research Center controllers fire Pioneer 11's thrusters to divert the spacecraft for a close inspection of Jupiter's south polar region.

5 Years Ago...

30 April 1979. The British Interplanetary Society moves to new Headquarters building in South Lambeth Road, London.

1 May 1979. Shuttle orbiter *Enterprise* mated with External Tank and Solid Rocket Boosters is moved to Launch complex 39A for compatibility checks with pad and gantry.

K.T. WILSON

MESSENGERS OF CREATION

We can now look at the sky with new eyes and see that the seemingly immutable stars are the scenes of violent activity. Stars collapse into white dwarfs and neutron stars, where the force of gravity is so great that it crushes atoms and, theory tells us, they eventually collapse into black holes from which not even light can escape. Stars explode into novae and supernovae. Quasars emit energy at all wavelengths at rates equal to a thousand galaxies and seem to be receding at velocities approaching the speed of light. All is not calm and unchanging out there.

By observing gamma-rays from the most distant quasars, we could be looking back thousands of millions of years. That will be the job of NASA's Gamma-Ray Observatory, due for launch towards the end of this decade.

The Crab Nebula, a source of gamma rays. *NASA*

The Violent Universe

Pulsars, like quasars, were first discovered by radio astronomy in the 1960's. They radiate energy in pulses, which suggests that the energy comes from a rotating body of enormous density and magnetic field and very small size, such as a neutron star. At least some pulsars, even though they were discovered by their radio emissions, radiate 100,000 times as much energy at gamma-ray wavelengths. Detailed gamma-ray observations may reveal the secrets of that colossal energy emission.

The death of a star, if its size is a few times that of our Sun, may take the form of a supernova. This is the explosion of the star after it has consumed all its nuclear fuel, blown off its envelope, and collapsed into a black hole. These extreme conditions create elements heavier than iron. The lighter elements are formed by the more conventional nuclear processes in stars. Much of the matter in our world is made only in this way. Gamma-ray observations of supernova remnants, such as the Crab nebula in our own Galaxy, will show us these processes in action.

Black holes have become a household word even though none has been observed. Cosmologists believe that a large number of mini-black holes may be left over from the original Big Bang. If we can prove they exist, then we will be closer to understanding how our Universe began.

The peculiar ring galaxy VV 285 has a violently active Seyfert nucleus (see text). *Kitt Peak National Observatory*

One way to identify a black hole is through gamma-ray observations, because the processes near a black hole will generate gamma rays of specific energies. We know what to look for, but only with instruments observing from beyond the Earth's atmosphere.

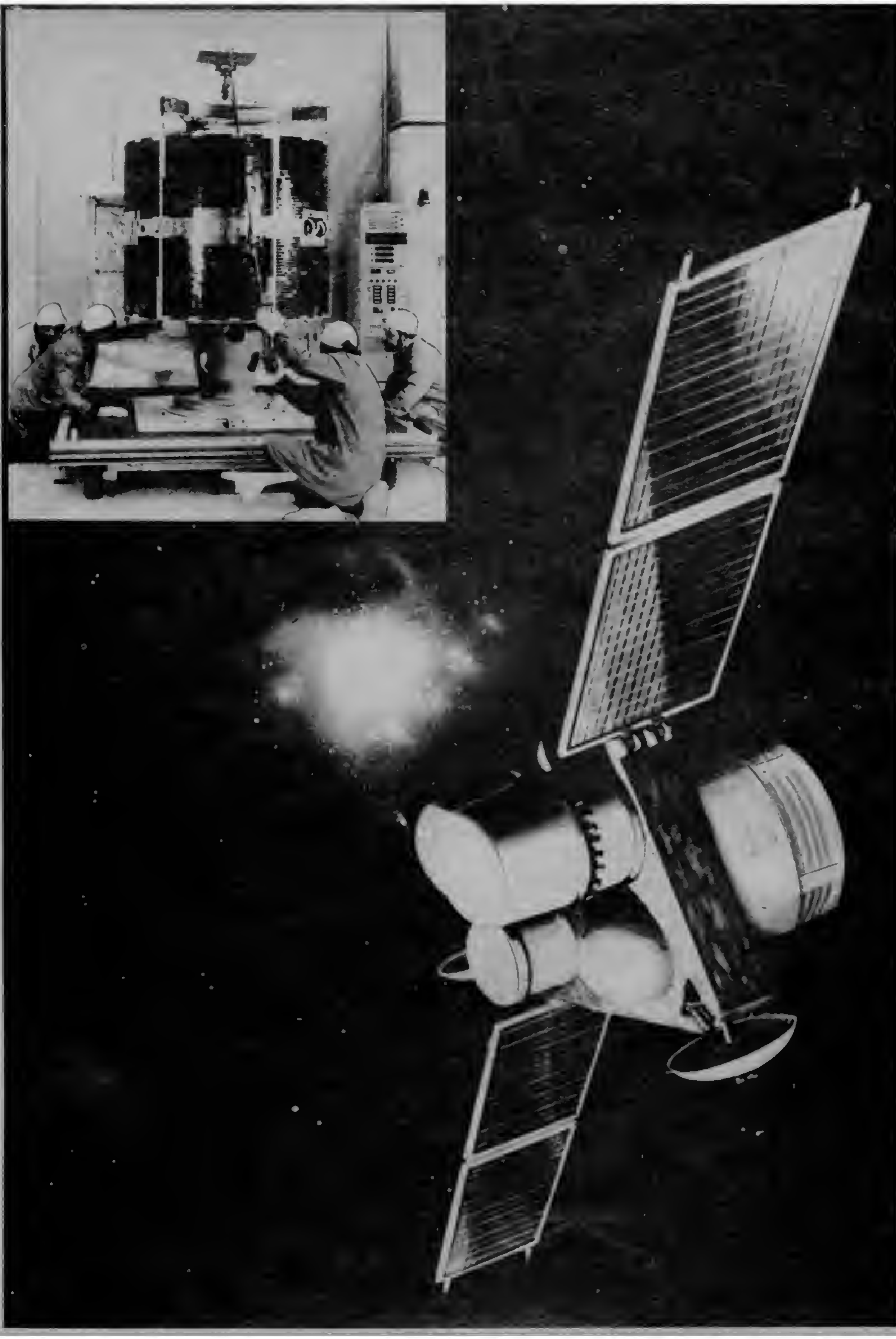
Theory suggests that the Big Bang left globs of anti-matter in the Universe. If they exist, we know that the annihilation radiation, resulting from the interaction with ordinary matter, will contain a certain type of gamma-rays.

Other interesting and evidently violent objects are the "active" galaxies. Quasars are one type, and it has been suggested that they might have black holes at their centres. Another is the Seyfert galaxy, which emits far more energy than a normal galaxy and varies in brightness for unknown reasons. It is expected they emit gamma-rays in addition to the X-rays already observed.

Another type of active galaxy is the radio galaxy; it seems ordinary in visible light but emits large amounts of radio energy at a varying rate. At least one has been observed to emit X-rays and gamma-rays, but more observations are needed to determine whether there are others and what processes are generating the energy. The same is true of the other type of active galaxy, the BL Lacertae objects. They, too, are variable, emit both radio and X-rays and are expected to be gamma-ray sources.

One of the most puzzling violent objects is the gamma-ray burster. Something is occasionally emitting bursts of gamma-ray energy, but so far no source has been identified with any other known objects. One possible exception is the unusual burst observed in 1979. Unlike others, it showed a series of pulses at 8-second intervals for almost three minutes. By a stroke of fortune it was observed by several spacecraft, and it was found that the burst came from the direction of the Large Magellanic Cloud. It may not have originated there, but if it did it emitted more energy in a tenth of a second than our Sun does in 10,000 years. This observation presents

A modified version of a booklet produced by TRW Inc; printed by kind permission.



a quandary for astrophysicists, who currently have no explanation for it.

The New Astronomy

Astronomers have been able to learn a great deal about the Universe by looking at it in the narrow part of the electromagnetic spectrum that we call visible light. They have determined its general structure and formed theories about its history. Since shortly before World War II, however, they have been looking at it in new parts of the spectrum. Radio astronomy was the first of these extensions, made possible by the transparency of our atmosphere to a large band of radio wavelengths.

Except for visible light, the atmosphere is largely opaque to other wavelengths, including gamma-rays. By travelling above the atmosphere, balloons and rockets have made observations for short periods. Earth-orbiting satellites have made it possible for the first time to conduct long-term observations from outside the atmosphere. The results have sent the theoreticians back to their blackboards. With a highly capable gamma-ray observatory, the entire window on the Universe will now be open.

Today's technology has enabled us to build larger and more sophisticated scientific satellites, with each step yielding an increasingly accurate and detailed picture of what is going on in the Universe. Now, with the advent of the Space Shuttle, we can launch the very large and complex orbiting observatories needed to increase the quality and accuracy of our observations. The Space Telescope with its 250 cm mirror is the first of these. The Gamma-Ray Observatory will be the second. The advantage of size is especially important for gamma-rays because they are relatively sparse and large instruments are needed to collect significant numbers of them in a reasonable period of time. They cannot be focused to form images and can be detected only indirectly, by their interaction with matter in the detector.

Several relatively small gamma-ray detectors have been flown on earlier satellites and have given us the first tantalizing glimpses of the wealth of information available. Their results have raised a host of questions that can be answered only by the larger, more sophisticated instruments on the Gamma-Ray Observatory.

Gamma Rays

Gamma-rays are a form of electromagnetic radiation, like radio waves or light rays or X-rays, but with shorter wavelength and therefore higher energy. All these forms of radiation have properties of both waves and particles. The particles are packets of energy (photons). Lower-energy photons are emitted when an electron changes energy level in its atom, but gamma-ray photons are emitted when the nucleus of an atom changes energy level. Photons are also emitted when a high-energy electron intereacts with matter, with a strong magnetic field, or with other, lower-energy, photons. Gamma-ray photons are also created when matter and antimatter meet, as when a positron and an electron meet and annihilate each other.

All these processes are going on out in the Universe, each producing gamma-rays with characteristic energies or a flux of gamma-ray photons with characteristic spectral shape. The excited nucleus in an element deactivates to lower energy levels and emits a gamma-ray photon, characteristic of the specific element. Gamma-ray astronomy is important because it can tell us what processes created the photons and what kinds of atoms were involved.

Because of the extremely short wavelengths of gamma-rays, we do not discuss them in the common terms of wavelength or frequency but use an equivalent measure: energy. Visible light measured in these terms has an energy in the range of one electron volt, while the lowest-energy gamma rays begin at a tenth of a million electron volts. We do not know how high gamma-ray energies can go, because they are at the top end of the spectrum, but they have been observed at thousands of millions of electron volts.

The Universe is largely transparent to gamma-rays. They can reach our detectors from the remotest parts of the Universe without losing energy or being deflected. Other forms of radiation tend to be dispersed by interstellar matter; for example, we cannot "see" the centre of our own Galaxy at other wavelengths because of all the intervening matter. The Gamma-Ray Observatory will help us to find out what is at the centre of the Galaxy and what is going on there.

The Gamma-Ray Observatory

We have referred to gamma-rays as another part of the spectrum, like radio waves or light or X-rays. The gamma-ray part of the spectrum is, however, much larger. The range of energies is over 10,000 times the range of visible light and over a 100 times that of X-rays.

The information we want is spread over the full range of gamma-ray energies. No single instrument could cover the entire range; GRO carries four different instruments, one of which will look for and measure gamma-ray bursts.

The low-energy range from a tenth of a million to ten million electron volts is covered by the Oriented Scintillation Spectrometer Experiment, which consists of four separate detectors that can rotate to look at different parts of the sky. One reason for this arrangement is that the background radiation can be measured and then substracted from the measurements of a point source. The sensitivity of this instrument will be over ten times better than that of any previously flown unit and it will be able to determine the direction of a source to a fraction of a degree.

The mid-range instrument is called the Imaging Compton Telescope. It covers the range from 1 to 30 million electron volts and will be able to determine angle of arrival to within less than a degree at the higher energies. It can measure the energy of the photons to within 5 per cent (also at the higher energies). Special provisions are made to reduce the background radiation effects.

For the highest energy range, from 20 million to 30 thousand million electron volts, the Energetic Gamma-Ray Experiment Telescope will be able to measure the position of a source to a fraction of a degree and the energy of individual photons to within 15 per cent.

Finally, the Burst and Transient Source Experiment will continuously observe the full sky (except for Earth blockage) for gamma-ray bursts or other short-duration phenomena. It will also make a full-sky survey of long-lived strong sources.

All of these instruments together weigh some six tonnes. The full observatory including these instruments will weigh about 15 tonnes. It has been designed to be launched, serviced and retrieved by the Space Shuttle. Every advantage has been taken of earlier experience to make the spacecraft as inexpensive as possible, using off-the-shelf components and proven designs.

The Gamma Ray Observatory at work. Target launch date is 1988, by the Space Shuttle. *Inset:* COS-B, a European satellite of the 1970's, was one of the first to study celestial gamma-rays. *NASA & MBB*

SHUTTLE 41B

By John Pfannerstill

A full report on Shuttle mission 41B will appear in a later issue. Here are a few basic facts on the trouble-plagued flight. The author's full Spacelab 1 report begins on p.212 of this issue.

Satellite Deployments

The main purpose of the mission was to release two commercial communications satellites: Western Union's Westar 6 and Indonesia's Palapa B2. The US craft was deployed on 3 February and things seemed to be going well until 45 minutes later when an automatic timer on the satellite's PAM fired the stage's engine to boost it to geostationary orbit. The motor apparently misfired, burning for only 8 to 10 seconds out of a planned 85. Instead of a 306 by 35,778 km orbit, Westar was tracked in a 352 by 1404 km path, rendering it essentially useless.

Spinning at 50 rpm the next day, Palapa sprang out of the bay, only to fail in exactly the same manner 45 minutes later. The trouble in both instances seemed to be with the PAM rocket nozzles, the similar orbits indicating a common failure. It was suggested that faulty treatment during production had caused the exit cones to shatter under the heat of the engine firing. Unfortunately, the PAMs transmitted no telemetry, giving engineers very little to go on.

Despite all the problems, it must not be forgotten that the Shuttle performed its part flawlessly.

Rendezvous Excercise

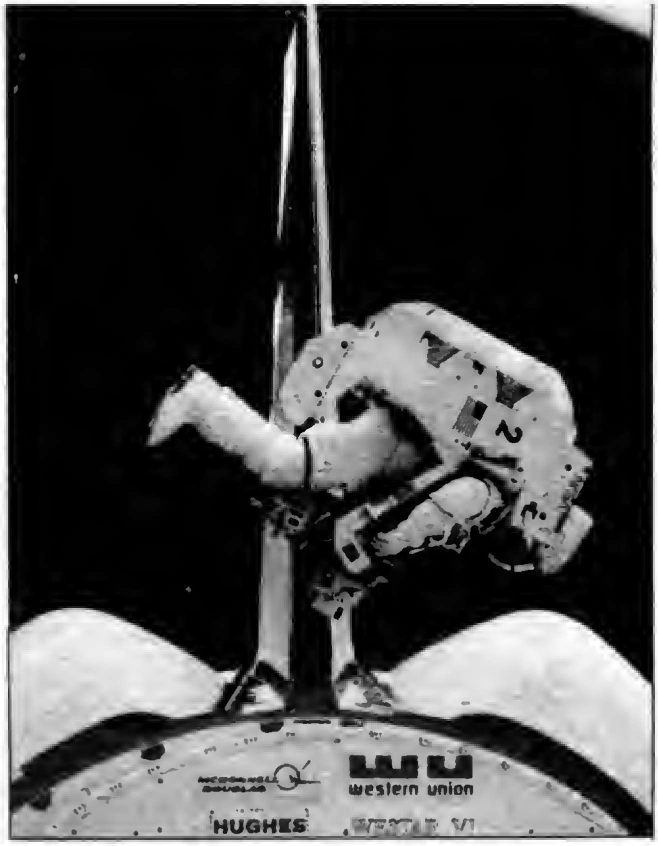
The mission was to have featured a rendezvous demonstration (the first for a Shuttle) involving manoeuvres with a 2 m diameter mylar balloon called the Integrated Rendezvous Target (IRT). But the plans were thwarted when the nitrogen-filled sphere ruptured shortly after release on 5 February. The astronauts should have spent the rest of the day backing the Orbiter off 260 km before performing a rendezvous on 6 February in a three-hour chase spanning two orbits. The exercise was to give *Challenger's* radar systems a workout in preparation for mission 41C's rendezvous with the Solar Maximum satellite in April.

Extravehicular Activity

The most exciting events were the two EVA periods on 7 and 9 February. Bruce McCandless and Robert Stewart spent over 12 hours outside *Challenger* checking equipment and techniques for use in the Solar Max EVA. Most important were the two 136 kg Manned Maneuvering Unit (MMU) backpacks. Both men flew the nitrogen-propelled packs first inside the payload bay then out as far as 97.5 m. With no umbilical or tether of any kind connecting them to the Orbiter, McCandless and Stewart became free-flying human satellites.

THE CREW

Vance brand, Commander
Robert Gibson, Pilot
Ronald McNair, Mission Specialist–1
Robert Stewart, Mission Specialist–2
Bruce McCandless, Mission Specialist–3



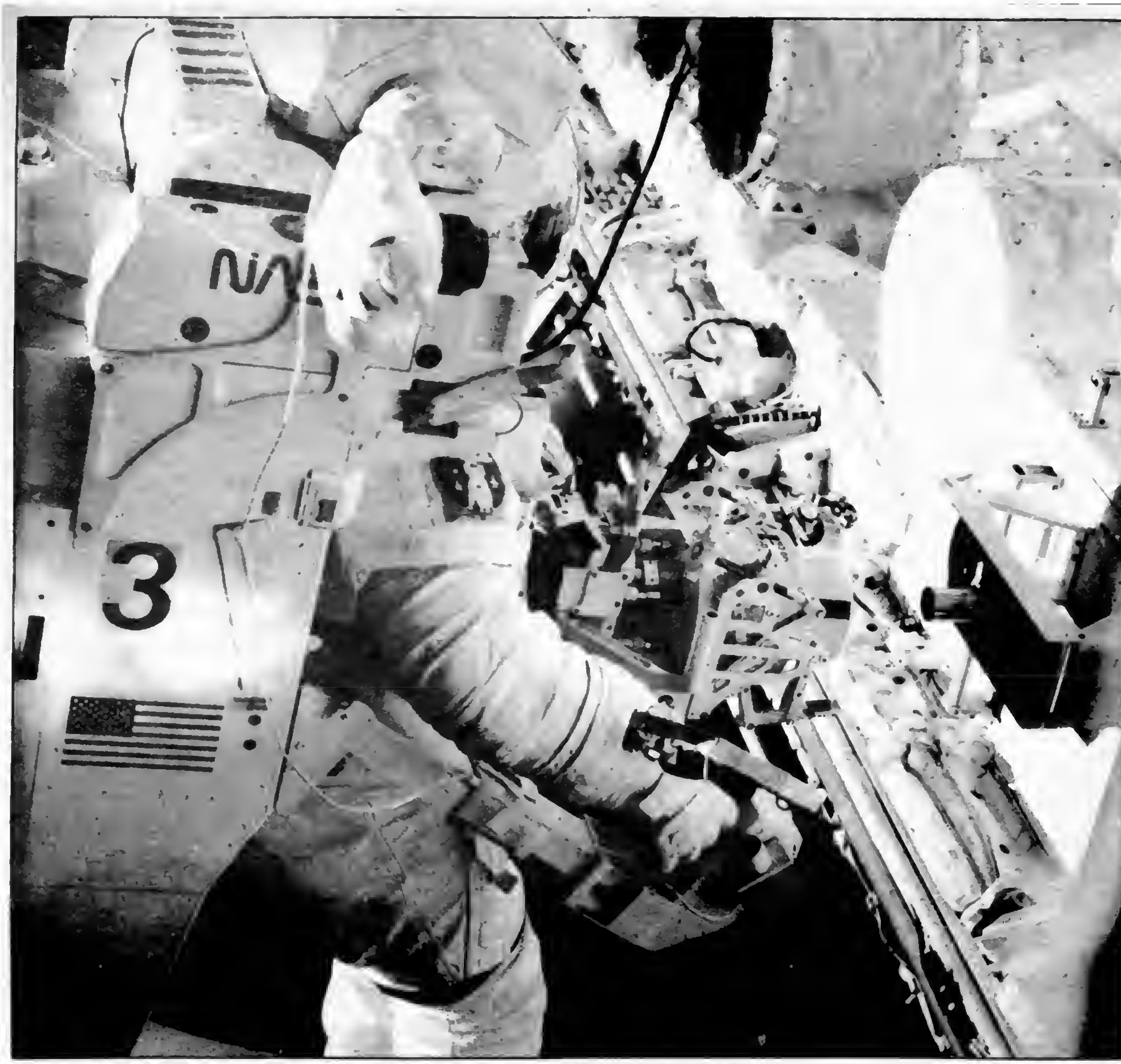
McCandless drifts lazily above *Challenger's* payload bay during MMU testing.

The two walkers made several tests in rehearsal for Solar Max. They mounted the Trunnion Pin Attachment Device (T–PAD) to the front of the MMU armrests and practised docking themselves with various targets in the payload bay, demonstrating how the 41C astronaut George Nelson was to dock himself to Solar Max on the repair flight. Failure of the robot arm's backup wrist joint cancelled more elaborate simulations. To simulate the actual repair, a mockup of the Solar Max main electronics box was mounted on the SPAS pallet so that the astronauts could demonstrate the procedures planned for 41C were feasible in space.

Stewart also demonstrated techniques to re-fuel a Landsat-type satellite with hydrazine. Using a mockup of a Landsat fuelling port attached to one of the work stations, he found he was able to make the proper connections without starting leaks. Red-dyed freon was used to check his plumbing job. An actual EVA fuel transfer demonstration using real hydrazine is planned for mission 41G in August.

On 9 February, while McCandless and Stewart were both out of the MMUs and safely secured to *Challenger* by tethers, a foot restraint broke loose from one of the work stations and floated off. Brand decided to demonstrate procedures he would have followed had either man been stranded away from the Orbiter by a failed MMU. After quickly checking that both walkers were secure, he manoeuvred *Challenger* over to the drifting piece of equipment. McCandless made his way to the aft end on handrails and grabbed the foot restraint and brought it back into the bay.

On 11 February, the crew brought *Challenger* down towards the Kennedy Space Center for the first-ever landing at the spaceport. Brand lined *Challenger* up with the end of runway 15 and brought the 100 tonne craft down with precision. The mission had lasted 7 d, 23 h, 15 m and 54 s.



Docking practice using the T-PAD. McCandless is shown approaching a target on top of the SPAS.

McCandless gives the MMU a workout during the first EVA period.

Release of Palapa B2.

NEWS FROM THE CAPE

The Latest Developments from Cape Canaveral in Florida

By Gordon L. Harris

BEYOND THE STATION

Even as President Reagan endorsed a permanent space station in his State of the Union address on 25 January, opposition appeared in rather unlikely quarters. Edwin "Buzz" Aldrin, who visited the Moon with Neil Armstrong in July 1969, called for a US lunar base as the preferred objective. Aldrin said, though, that today's Shuttles cannot support the Moon project without another propulsion vehicle, possibly the long-discussed space tug.

"The Solar System's most desirable space station already has six American flags on it," Aldrin said. "Let's use it and not turn it over to foreign pioneering frontiersmen."

An Associate Press report from Washington indicated the ex-astronaut has supporters. Dr. George Mueller, Apollo programme chief, would eliminate the space station in favour of lunar development. Still others, want both a station and a lunar base.

White House science advisor George Keyworth has said that NASA should be planning beyond a space station, or planning how to use one to fly men to the Moon and perhaps to Mars.

The publicity recalls the US Army's secret Project Horizon put forward 24 years ago. It proposed using Saturn rockets to establish and support a permanent lunar base for research purposes.

In July 1969, addressing a US Senate panel, Wernher von Braun suggested development of nuclear powered Shuttles for a two-year expedition to Mars and return.

So much for "new" initiatives!

LAUNCHES THIS YEAR

NASA plans 9 Shuttle missions in 1984, twice the number of manned flights in any previous year: five Geminis were flown in 1965 and 1966.

During May, Intelsat 5A–A will be launched by Atlas Centaur from Complex 36, and NATO–3D will be flown on a Delta for the North Atlantic Treaty Organisation.

Discovery, the third orbiter, makes its debut on 4 June on Mission 41D. During seven days in space the crew will operate a Large Format Camera; NASA's Office of Aeronautics and Space Technology will sponsor the OAST–1 pallet and two communications satellites will be released: Telesat I for Canada and Syncom 4–1 for the Hughes Company.

Galaxy–C, a Hughes commercial communications satellite, will also be launched in June by a Delta vehicle.

Three unmanned launches and two more Shuttle flights are on the August schedule. NOAA–F, for meteorological observations, will be launched into polar orbit from Vandenberg. Intelsat 5A–B will be carried on an Atlas-Centaur and the Active Magnetospheric Particle Tracer Explorer, a space physics investigation in cooperation with West Germany and the UK will be carried on Delta from KSC.

On 9 August Mision 41F, a seven-day flight of *Discovery*, will involve the first autolanding at Edwards Air Force Base, California. Payloads include Spartan–1, a new class of small astronomical devices that would usually fly aboard a sounding rocket, and three communications satellites: SBS–D for Satellite Business Communications, Syncom 4–2 for Hughes and Telstar 3C for American Telephone & Telegraph Corp.

Mission 41G, a 10-day flight of *Columbia*, will begin on 30 August. Cargo includes OSTA–3, the Earth Radiation Budget Experiment satellite and Sparx–1, a commercial remote sensing device.

Navy 22 will be flown on a Scout from the Vandenberg pad during the third quarter of 1984.

Challenger will return with Mission 41H on 28 September. The payload will either be a Defence satellite or the second Tracking and Data Relay Satellite of NASA's new worldwide communications system.

Mission 51A with *Discovery* is scheduled for 24 October. Payloads for the six-day flight include a Materials Science Laboratory, sponsored by the Marshall Space Flight Center; GAS Bridge, a structure installed across the payload bay to hold more Getaway Special canisters and the Telesat-H communications satellite for Canada.

Challenger will fly Mission 51B, beginning 21 November for seven days with Spacelab 3, billed as the first operational flight of the ESA payload.

Intelsat 5A–C will be launched by Atlas Centaur during November from KSC.

The US Air Force will sponsor AF–16 (ITV–1) carried on Scout from NASA's Wallops Island (Virginia) facility in the last quarter of 1984.

Another Scout will launch San Marco D/L, a cooperative project with Italy, from the San Marco range off the coast of Kenya in December.

Mission 51C with *Discovery* will conclude a busy year. Beginning 17 December, the flight will last seven days and will carry TDRS–B or TDRS–C plus the Materials Science Laboratory.

PAYLOAD SPECIALISTS

Spacelab 1 introduced a new, human, factor into manned space flight: the payload specialist who, unlike pilots and mission specialists, is not a member of the career astronaut corps.

Even more important to NASA's management scheme, his (or her) selection by scientists broke with long standing policy and tradition. The payload specialist supposedly comes from the space science community and is a member of the principal investigator (PI) teams that developed Spacelab experiments.

Two US specialists were chosen for the first Spacelab from PI teams: Dr. Byron Lichtenberg, who flew in STS–9; his speciality was Dr. Lawrence Young's vestibular function experiment, and Dr. Michael Lampton (backup), who worked Dr. Stuart Bowyer's far ultraviolet telescope.

The European Space Agency's specialists, Dr. Ulf Merbold of Germany (flight) and Dr. Wubbo Ockels of the Netherlands, were chosen by a different procedure. So

The four Payload Specialists of Spacelab 1. From left: Ulf Merbold, Byron Lichtenberg, Wubbo Ockels and Michael Lampton. Merbold and Lichtenberg actually flew; the others acted as backups. Since NASA is planning to refly some of the Spacelab 1 experiments (the late launch date degraded their results), two of the four might be chosen to go aloft rather than train others afresh. *NASA*

was Dr. Claude Nicollier, who was later taken from the group for full-time assignment at the Johnson Space Center. The final selections were made by investigators' working groups (PI teams).

While pilots and mission specialists are primarily responsible to NASA, Lichtenberg pointed out that payload specialists "have primary responsibility to the scientists." In his opinion, the value of Spacelab 1 was as a demonstration of scientists on Earth interacting with their peers on orbit. If that happened, "we will have paved the way for future participation of scientists on the ground."

Ockels and Lampton represented the payload specialists during the mission, evaluating what happened in space, how busy their colleagues were and what problems they encountered. "We were a filter," Ockels said.

Lampton found that only six weeks is enough to train a payload specialist in Shuttle life: how to use the toilet, prepare meals, escape after crash landing and other fundamentals. "A payload specialist," he observed, "only needs to know where his suitcase is."

While astronaut John Young flew 1,800 landing approaches in a Shuttle trainer before STS-1, Merbold remarked "We do not have the luxury of so many hours in a simulator. We would be in a better position with additional training."

The next payload specialist will be Charles Walker of the McDonnell Douglas Co., who will operate the continuous flow electrophoresis system during a 70-hour pilot production run in the June mission 41D. Two more Spacelab payload specialist crews are in training, but only two of the four candidates will actually fly.

Spacelab 3 in November will concentrate on low gravity physics and materials processing. Drs. Mary Johnston of Marshall Space Flight Center and Leodwijk van den Berg of EG&G Corp. are candidates selected by crystal growth scientists. Drs. Taylor Wang and Eugene Van Trinh of Jet Propulsion Laboratory are nominees of the drop dynamics module team.

Spacelab 2 in March 1985 will deal with solar physics and astronomy. The specialist candidates, all solar physicists, are Drs. Loren Acton of Lockheed's Palo Alto Research Laboratory, George Simon of the US Air Force Sacramento Peak Observatory, and Diana Prinz and John David Bartoe of the Naval Research Laboratory.

There is a chance that all eight will fly if Spacelab 3 equipment is reused on Spacelab 8 in 1988 and if the

Sunlab flight in 1986 reuses Spacelab 2's telescope. But NASA is not committed to carrying payload specialists on these missions. Nor has the agency announced formal plans for Spacelab 4, a life sciences mission in 1985, or a series of ultraviolet telescope missions in 1986–7.

THE NASA BUDGET

The NASA budget presented to Congress on 1 February requests $7,370 M for FY 1985 (1 October 1984-30 September 1985), including $150 M for engineering and definition studies leading up to a permanent space station in the early 1990s.

Administrator James Beggs said that the Reagan Administrations wants to hold space spending at about the same level for several years, allowing only a 1% increase annually. He mentioned the following for the next year:

- Continued progress on the Hubble Space Telescope, the Galileo mission to Jupiter, and the Venus Radar Mapper;
- Important new projects: a Mars Orbiter and Upper Atmospheric Research Satellite;
- 13% increase in aeronautical research and technology development;
- Shuttle flights will increase because of paying customers: 7-8 missions in FY 84, 11 in FY 85, 16 in FY 86, continuing to increase through to 1989;
- Second and third Spacelab missions;
- Launching the second and third Tracking and Data Relay Satellites to complete the new communications system;
- Delivery of the fourth orbiter, *Atlantis*, in December and continuing Rockwell's production line for structural spares;
- Continuing efforts to modify the Centaur as an upper stage for Shuttle missions;
- Improving Shuttle propulsion, especially main engine reliability and solid rocket booster performance;
- Continued development of the US-Italian Tethered Satellite;

Of the new "starts," Beggs said, "We have been developing instruments for a satellite that would, for the first time, make a comprehensive, global measurement of the stratosphere. The budget enables us to begin the Upper Atmospheric Research Satellite.

"The Mars Geoscience/Climatology Orbiter will be launched in 1990 and is the first of a series of relatively low cost "Planetary Observers" designed to investigate specific questions in planetary science."

Answering press queries, Beggs said that:

- The Shuttle fleet should begin to break even (cost of operations *vs* tariffs paid by customers) in 1988–89;
- He expects substantial investment in the space station by private industry. ESA, Japan, Canada and "other countries" are very interested in participation;
- He anticipates a time, some years hence, when customer demands will justify a fifth orbiter;
- "Manned trips to Mars and lunar base" are in "our dreams."
- Space station funding will increase to $200-$250 million in FY 86, reach $1.2 billion by FY 87 and increase to $2 billion annually;
- No funds for Atlas Centaur and Delta rockets are in the new budget. NASA has received an acceptable proposal from General Dynamics to continue Atlas Centaur as a commercial venture, while another proposal has been received from TCI, a new firm, for Delta operations. These should become completed within a few months.
- Congressional reaction to the space station has been favourable but not unanimous and "we will have a job to do," Beggs concluded.

AS EXPECTED...

Newspapers in the Cape area were much more impressed by the presence of Steven Spielberg and George Lucas, producers of *E.T.* and *Star Wars*, at the STS-9 launch rather than by ESA officials and members of the US Congress whose votes are essential to the NASA progrqammes. With the two bearded Hollywood men came John Denver, actor-singer, who also drew notice from the youthful reporters.

ESA sent Erik Quistgaard, director general; Michael Bignier, Shuttle director; George van Reeth, administrative chief and Jean Albert Dinkespiler, of the European Communities commission. From Italy came Minister of Research Luigi Granelli. From France Jean Loup Chretien and Patrick Baudry, cosmonauts (or 'spationauts' as the French like to call them). From Switzerland, Ambassador Aomin Kamer; from Austria, Prof. Johannes Ortner, president of the Solar and Space Agency. President Nimeiri of Sudan was the only foreign head of state at the launch site.

SECOND SHUTTLE PAD

Preparing for an accelerated launch schedule, KSC is continuing modifications to Pad B, Launch Complex 39. The latest action was a contract for $4,250,000 awarded to Planning Research Corp. and Briel, Rhame, Poynter & Houser for architectural and engineering services. The work will be completed by 1 February 1986 and brings to $14,433,321 the total awarded to the joint venture since December 1982.

NASA PUBLICITY

NASA continues to use radio and TV for spreading space information by distributing TV tapes to its centres, 650 TV stations and 425 cable systems *via* the RCA satellite "Cablenet 1." Five hundred TV stations receive a 4½ minute programme, the remainder receive a "90 second spot" which is a condensed version. As an example, the October 1983 release was "Ear on the Universe."

Radio programmes are sent to 3,500 stations; the October version was a "Space Story" running for 4½ minutes. Translations are made for broadcast overseas. Each month the agency supplies one 14½ minutes report and four weekly stories of 4½ minutes.

AN OPPORTUNITY TO SEE SPACE HISTORY IN THE MAKING

HALLEY'S COMET PROBE VISIT

When Halley's Comet plunges past the Sun in February 1986 it will be heading towards a meeting with several spacecraft from Planet Earth. One of these will be Europe's *Giotto* probe.

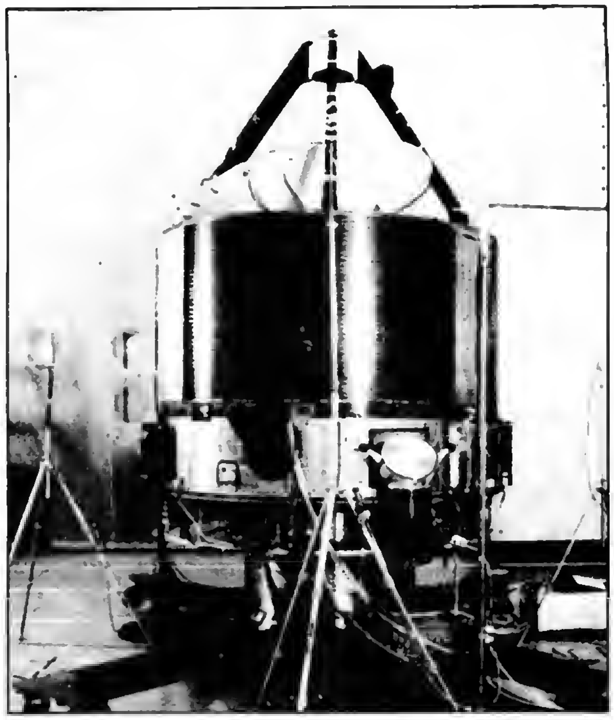
Society members now have the opportunity of visiting British Aerospace in Bristol to see this unique craft under construction. This is a once-in-a-lifetime opportunity to inspect the probe that will provide Man with his first close-up views of these celestial wanderers, and of particular interest to those who plan to go on the Halley's comet tour to South Africa later on.

The visit will last for three hours beginning at 4 pm:

1. Introduction and Welcome,
2. Briefing on BAe involvement with Giotto,
3. Viewing of the Giotto probe.

No cameras will be allowed.

Since the party has to be limited in numbers, places will be allocated on a first-come-first-served basis. The visit will take place on Wednesday, **23 May 1984** from 4.00 to 7.00 p.m. Registration forms can be obtained from the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Rd, London SW8 1SZ. Please enclose sae.



The Giotto structural model undergoing acoustic tests.

ARE YOU MISSING OUT . . .

. . . on the information and excitement of *Space Education?*

The first of this year's *Space Education* issues includes a range of articles on the teaching and philosophy of astronautics, as well as 'hard' space information.

Professor Bettye Burkhalter *et al* describes the world's largest space camp for children, while Paul Maley and Geoffrey Perry discuss space activities that are not only educational but fascinating to carry out.

An amateur space telescope for launch aboard the Shuttle is described by one of its managers and details on how the astronauts actually cope aboard the reusable spacecraft are presented in "Living aboard the Space Shuttle."

European work in remote sensing is covered, while Frederick Ordway concludes his series on collecting space books.

Copies of *Space Education* are available at £2 ($4) each, post free from The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ.

AS GOOD AS GOLD...

... and just as valuable

By Michael Wilson*

Building satellites is a very expensive business. They are such valuable items that, once in space, they have to be relied upon to do their job without fault. The exciting times of the early days, with major discoveries being made on almost every flight, has given way to hard commercialism in which satellites are just part of better long-distance communications, weather forecasting, navigation or plain office efficiency. The most expensive commodity of all — reliability — has been secured.

Introduction

Satellites are unique among electronic or electromechanical devices in that, once in position, they are required to work through a seven or ten-year lifetime without so much as a single visit from the maintenance man.

The reliability aspect is perhaps best clarified by comparing spacecraft with aircraft, their nearest technological neighbours. A typical communications satellite costs about $30 million to build, about the same as a medium size airliner. Yet its weight, at around 1,400 kg, is only about two per cent of the latter's. The cost/weight discrepancy is attributable to two factors: the proportionately greater outlay needed at the design and testing stage, and the small production run. The satellite builder plans on a run of perhaps a dozen, incorporating "one-chance" technology. Reliability has to be built in and guaranteed from launch. There is no possibility of a year-long development flight programme to check performance and sort out problems as with aircraft.

With the Shuttle it is now possible for spacecraft to be retrieved from low orbit and brought back to Earth. The Landsat 4 Earth resources satellite, launched in July 1982, experienced so many failures in its first year that plans are being made to return it for investigation.

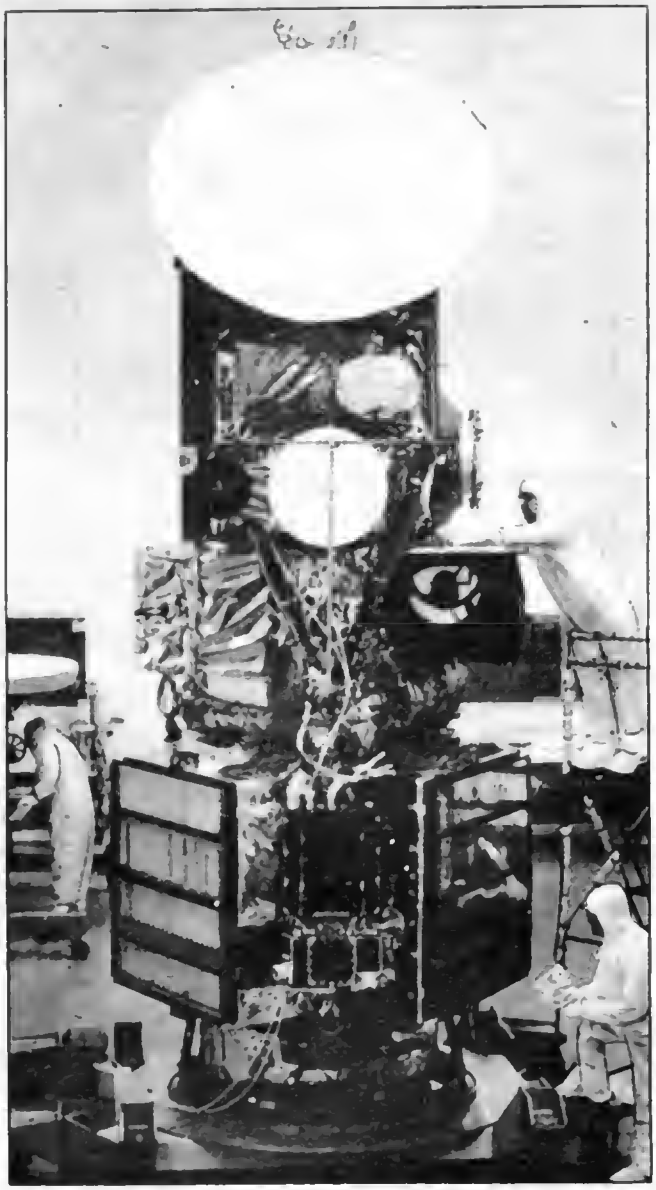
Nevertheless, retrieval from orbit for a run-of-the-mill communications satellite is expensive. Neither is it a short-term step, since the vehicle is booked up months in advance.

The word "reliability" has a certain finality about it. A description that better fits what the user really wants is "continuity of service." It is the day-to-day dependability of the service as a whole that organisations such as Inmarsat and Intelsat are required to provide. Ultimately, the credibility of the service hangs on the reliability of the complex electronic devices hanging in space 36,000 km away.

Building the Satellites

The satellite design team has a number of tools to assist it in establishing the reliability of its product. First and foremost is a background of successful previous designs and a knowledge or even feel for what makes for good or bad design. As in aviation, so much new technology becomes available between successive generations of satellites that each new project may call for a fresh approach in many areas.

Failure-mode analysis at all stages in the design is now a sophisticated and powerful method of investigating the integrity of equipment and pin-pointing likely areas of weakness long before it is even built and how these would react, domino-like, on other systems and equipment. This technique is associated with another method of ensuring long life, which is component, circuit or system redundancy. In this most effective antidote against unreliability, components are doubled-up, triplicated or even quadruplicated so that failure of one, or even two, leaves the others to maintain the function without additional strain.



The Landsat 4 Earth resources satellite failed in orbit, forcing its replacement by the 4-prime craft in March. One of the problems was with cables routing power from the solar panels. Previous satellites in the series had all worked well, stretching back to 1972. *NASA*

With redundancy, particular care has to be exercised to avoid what are termed "common-mode" failures that could affect supposedly independent systems and equipment. An example of increasing importance is the way in which undetected errors in computer software can cause each channel in, for example, an attitude control system to go wrong one after another in exactly the same way. The most rigorous verification of software is called for in such applications. Again, the designer must exercise fine judgement in the application of redundancy: excessive caution increases the cost of the satellite and makes it bigger and heavier than need be.

Considerations of weight and space impose major constraints on designers. As users demand more capacity

* Consultant Editor, Janes Publishing Co. This article was first published in *Ocean Voice* (Inmarsat) and appears here by kind permission of the Editor.

and better performance satellites tend to become bigger and heavier. To an extent this growth can be met with continuing improvements to launch vehicles. The US Delta rocket is a fine example of how rocket performance has kept pace with user requirements. At any given time, however, the designer has a limited space available within the payload shroud and a maximum weight allowance that he must not exceed. While larger rockets may be available, the relatively small range of available vehicles means that the next one up in size will probably be much more costly to buy and launch.

Any small increase in weight to a spacecraft subsystem has a "knock-on" effect out of proportion to the magnitude of the change. For example, the designer may be obliged to add a printed circuit board to improve the performance of a system in some way. This may well mean a new and bigger case that will not only weigh more but may encroach on the space needed for adjacent equipment. The stress calculations may have to be repeated to make sure that the supporting structure or shelves are now strong enough and the system may need more power to drive it and more cooling methods to keep the temperature within limits. The extra weight, again, may unbalance the satellite to the extent that relocation of other equipment may be needed to restore the original, finely balanced condition. Depending on circumstances, a weight increment of 0.1 kg can result in a final weight increase of perhaps 1 to 10 kg, a thought-provoking magnifying effect.

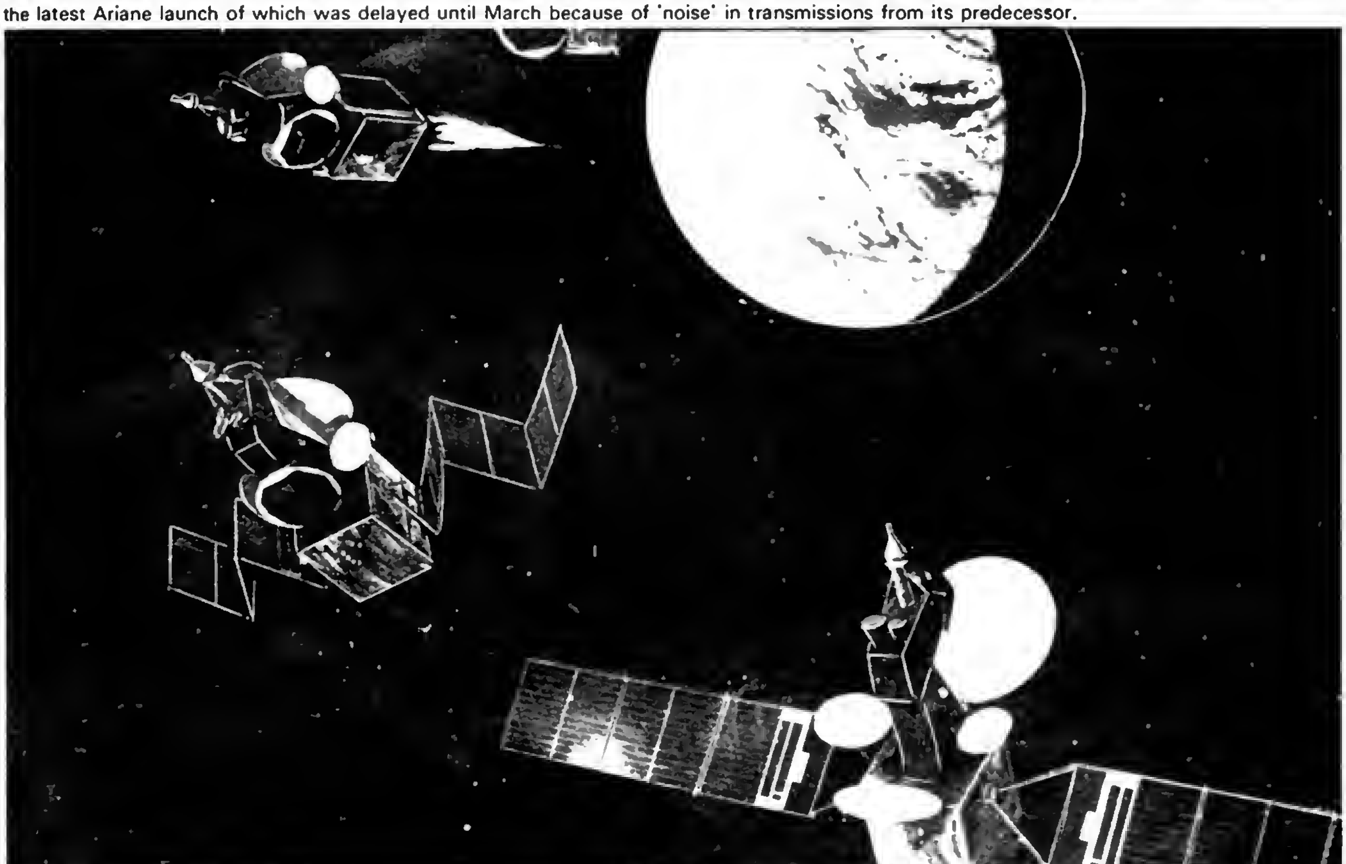
While redundancy is a powerful way of ensuring reliability, it is not always a practicable one. Mechanical devices such as apogee motors or attitude thrusters are difficult or impossible to "double up" and have to be 100 per cent reliable. Such devices, fortunately, are usually robust and — provided they withstand the harsh vibration and acoustic noise during launch — have a virtually infinite life.

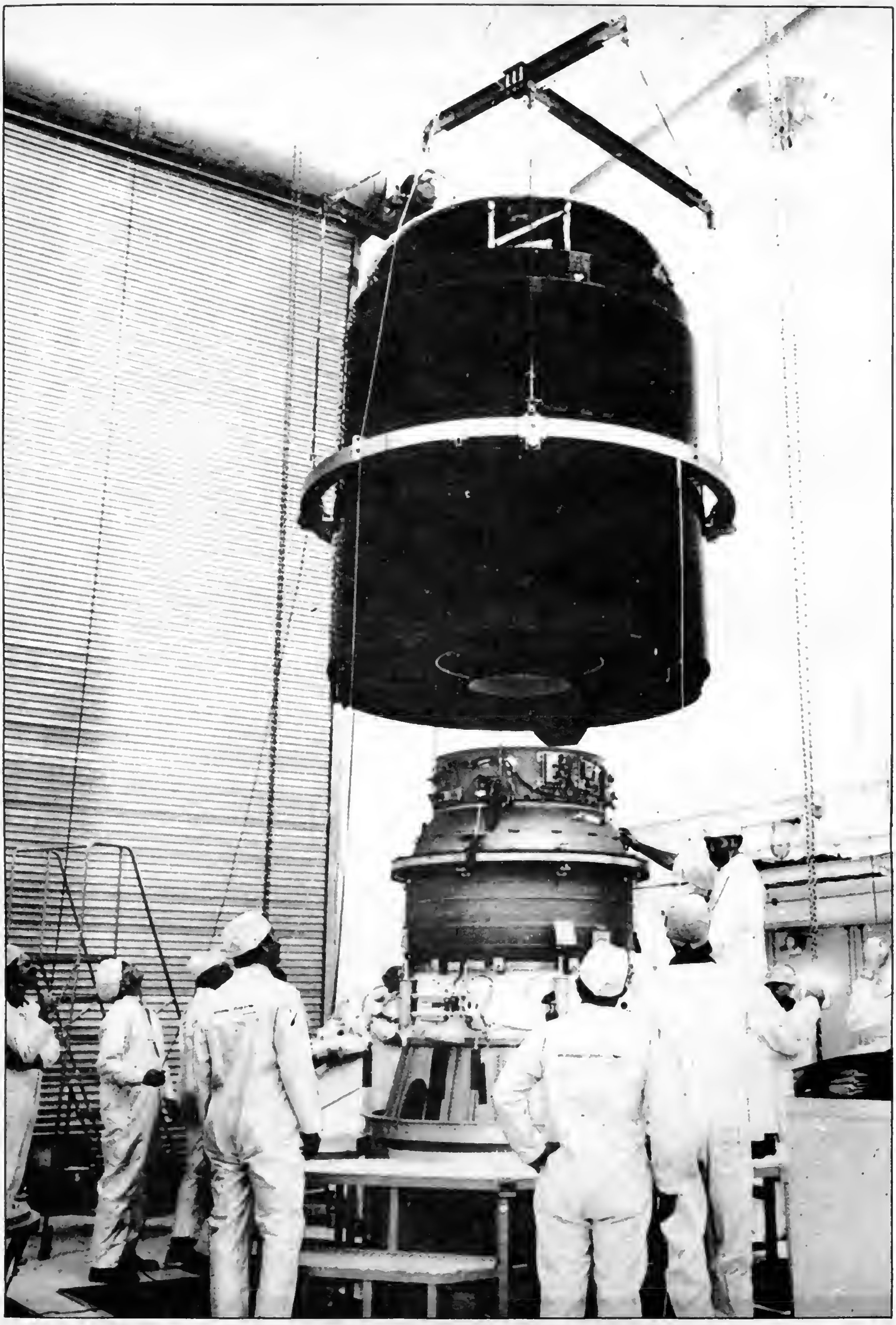
Once design has been finalised it is translated into hardware and tested on the bench, faults being fed in to check the earlier fault-analysis predictions. Individual systems are tested in isolation and then brought together to check that they do not interefere with one another electrically, mechanically, operationally or in any other way. This process is part of what is known as systems integration. An engineering model is built, as near as possible in standard to the actual flight model satellites, so that more representative tests can be made. This model is usually maintained in working condition during the life of that family of satellites so that faults or anomalies that show up in orbit can be investigated or simulated in the most realistic way to see whether remedial action can be taken to restore health. It may be that the control software, for example, or the operating mode of the spacecraft can be changed so that the fault can be rectified or bypassed.

Another complete spacecraft that will also never actually fly is built to check the way in which the various parts and systems heat up, cool down or maintain their temperature in the space environment. This demands a large vacuum chamber and comprehensive control and test equipment, an expensive investment for any company in the satellite business and one reason why these vehicles cost so much by the standards of every-day engineering.

As spacecraft becomes more complex and the demand increases for greater operational lifetimes, so it becomes more important to know how healthy a satellite's systems are from day to day. Test signals and measurements are made at critical points and telementered back to Earth so that the overall performance of the satellite can be monitored continuously and dangerous trends (e.g. a steadily rising temperature in some system or component) discovered. Bad news such as this, if detected early, can

A vital part of a communications satellite's life is the journey from low Earth orbit up to its operating altitude 36,000 km high. The 'burn' of the rocket motor to begin the trip has to be exactly right or the satellite could end up in an unusable orbit. This happened to the Westar and Palapa satellites released from the Shuttle in February - the attached solid rocket motors are thought to have failed. The illustration shows an Intelsat 5, the latest Ariane launch of which was delayed until March because of 'noise' in transmissions from its predecessor.





help to buy time for a possible salvage operation through Earth-based simulation or investigation.

Another relatively powerful method of improving reliability is the "burning in" of electronic components before they are assembled together into a piece of equipment. By applying the appropriate electrical power to the component for a period of hours or days, sub-standard examples can be induced to fail before selection. This weeding out of components prone to early failure, or "infant mortality" as it is termed, can result in as much as a 100-fold improvement in reliability for very little extra cost.

Components for satellites are always of the highest quality available and are purchased only after the most stringent evaluation of the manufacturer, his management capabilities, production methods and technology and quality-assurance policy. Satellite designers prefer as far as possible to buy "off the shelf" components known to work reliably under military or industrial conditions. The high volume of production for these markets ensures a good basis for assessing reliability on statistical grounds, while the devices themselves are incomparably cheaper than custom-built equivalents that may eventually prove to lack the anticipated standards.

But even the highest quality components start off at the bottom of the ladder where spacecraft are concerned. All have to undergo extra tests to make sure that they are compatible with conditions in the rocket and outside the Earth's atmosphere. The space environment is characterised by a hard vacuum that imposes conditions on equipment which in the early days led to frequent failures and can even now spring surprises.

The lack of atmospheric pressure causes conventional lubricants to evaporate away so that bearings run dry and seize up after only a short period. For rotating devices, such as momentum wheels that need to run continuously throughout flight, bearings have to be designed to run without lubrication at all. Instead of grease, the bearing surfaces are coated with a special metal plating.

Again, the designer has to be choosy; some plating materials with otherwise acceptable qualities in this respect fall down in unexpected ways. Cadmium, for example, starts to grow metallic whiskers in a vacuum, with the potential risk of a disastrous electrical short-circuit.

Again, the plastic commonly used as the insulation medium for electrical cables may give off gases that can pollute the surfaces of nearby equipment or sensors, while the insulation itself may become brittle and crack, thus losing its essential electrical properties. The long-term behaviour of likely plastic materials therefore has to be established in the laboratory before it can be trusted on a satellite. If a suitable type cannot be found ready-made then it has to be developed, a most expensive undertaking for the relatively minute quantities involved in space activities.

Paint may likewise undergo changes, for example changing colour or becoming crazed (the surface gradually breaking up into network of fine cracks). Paint on satellites has a far more important function than decoration — it is often a carefully devised way of controlling the temperature of a piece of equipment. Any changes can upset the heat flow, increasing the risk of a failure somewhere.

The subject of heat flow, never far from the designer's mind, calls into view another aspect of the space environment — the lack of air to remove, by process of convection, excess heat from equipment. The side of a satellite facing the Sun may have a temperature of 150°C, while the side facing into dark space may be at −150°C. Both temperatures can be damaging to the spacecraft and its systems, so the designer has to provide conduction paths whereby heat can be moved as required, judiciously permitting some equipment to warm up at the expense of other systems that may tend to run too hot. Any excess net heat has to be lost by radiation from special surfaces.

Sometimes these passive methods of ducting away unwanted heat are inadequate and some of the precious weight and volume allowance has to be sacrificed to an active cooling or refrigeration system. On the other hand, maintaining an adequate temperature may be the problem and combination metal/plastic blankets have been developed to prevent undesirable loss of heat. Small wonder then that over the years heat-transfer management has become a highly specialised subject, demanding as much expertise as any other area of space engineering.

Another characteristic of supposedly empty space is that it is everywhere criss-crossed by a great variety of radiation and elementary particles from the Sun, stars and galaxies and some of these can hurt delicate equipment. The main offenders are protons (the nuclei of hydrogen atoms) and alpha particles (the nuclei of helium atoms, having four times the mass of protons). These particles are ejected at all times from, in particular, the Sun, especially during sunspot activity or when it is covered with violent eruptions known as flares.

The gradual deterioration of electrical output from solar cells as a result of the cumulative damage caused by such bombardment has been known for many years and new types of cells are much more resistant to such damage. Inside the satellite itself judicious shielding can be employed to protect sensitive components and systems.

Notwithstanding the decades of experience behind them, designers can still be caught out. Europe's first Meteosat weather satellite was struck by a blast of radiation, causing obvious distress a few seconds later, and it has not worked properly since. Even the much later Marecs satellite had some of its components disrupted by a massive shower of high-energy particles just after launch. But the design of the spacecraft allowed for such an event and the vehicle has continued to serve its shipping customers satisfactorily.

Damage by the much larger solid particles known as meteoroids is always a potential hazard, particularly if the satellite's orbit crosses the path of a comet or meteor shower. Such particles may come in from outer space with velocities of up to 35,000 km/hr. If they appear from a direction opposite to the direction of the spacecraft's motion, they may collide with a relative velocity of around 65,000 km/hr or more. Fortunately, even the smallest particles, no larger than grains of dust, are very rare and become increasingly so as size increases.

As part of its task the service organisation managing the satellite network has to take into account the reliability of the rocket during the launch phase. Regrettably, launch accidents still occur. It was a matter of acute disappointement that the second Marecs satellite now lies at the bottom of the Atlantic as the result of just such an accident. The possibility of such setbacks has to be taken into account by the satellite authority and sufficient redundant capacity provided to maintain whatever level of service has been contractually agreed. It is a great help if the satellite fails in a "graceful" way, with a degradation period of several months, so that a replacement can be booked into the launch vehicle schedule. A spare satellite kept in storage on the ground is preferable to one in

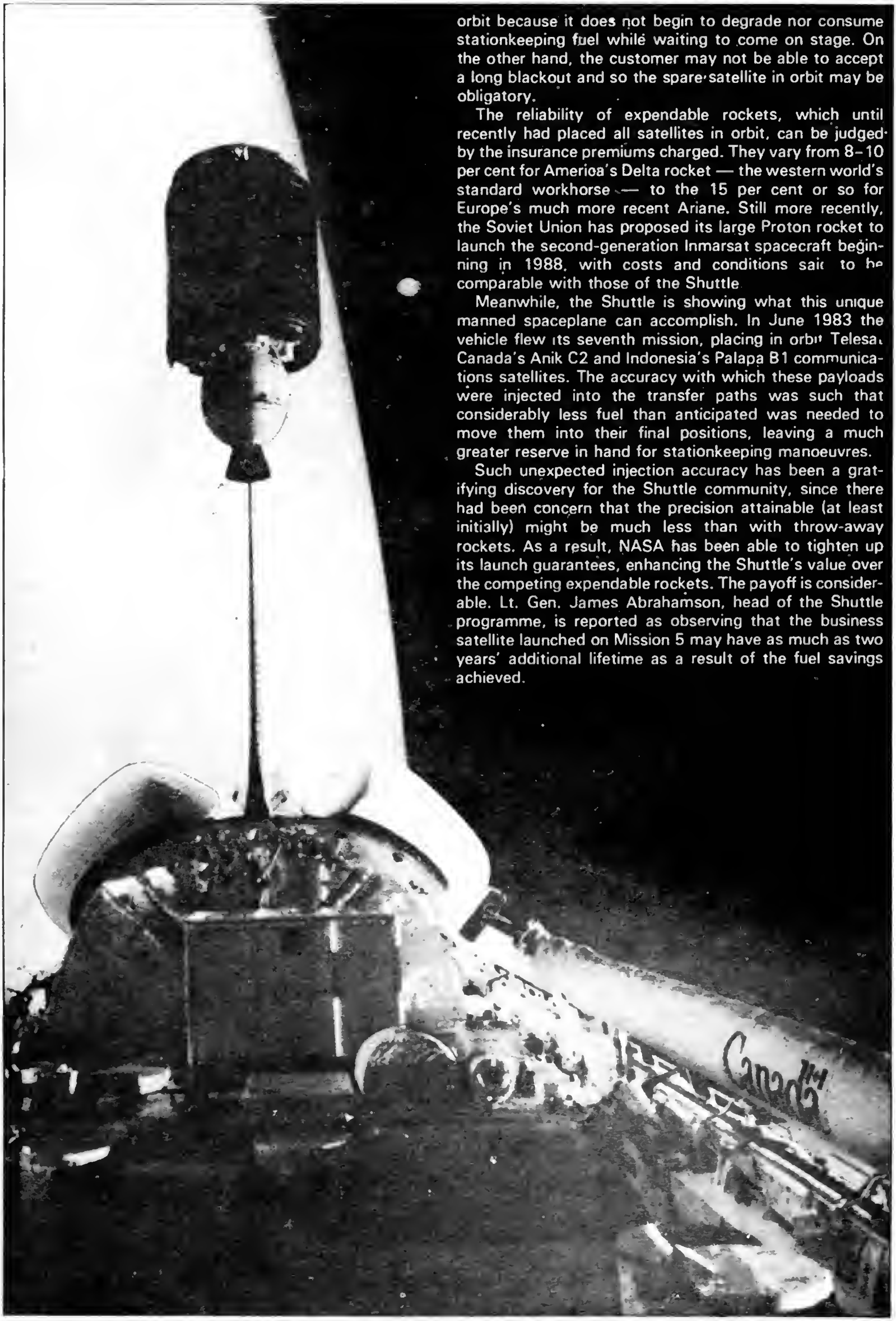
Facing Page: the SBS-A communications satellite is lowered on to its Payload Assist Module in 1980. The same combination failed twice in Shuttle mission 41B in February, prompting intense investigations and leading insurers to raise their premiums for future launches.

orbit because it does not begin to degrade nor consume stationkeeping fuel while waiting to come on stage. On the other hand, the customer may not be able to accept a long blackout and so the spare satellite in orbit may be obligatory.

The reliability of expendable rockets, which until recently had placed all satellites in orbit, can be judged by the insurance premiums charged. They vary from 8–10 per cent for America's Delta rocket — the western world's standard workhorse — to the 15 per cent or so for Europe's much more recent Ariane. Still more recently, the Soviet Union has proposed its large Proton rocket to launch the second-generation Inmarsat spacecraft beginning in 1988, with costs and conditions said to be comparable with those of the Shuttle.

Meanwhile, the Shuttle is showing what this unique manned spaceplane can accomplish. In June 1983 the vehicle flew its seventh mission, placing in orbit Telesat Canada's Anik C2 and Indonesia's Palapa B1 communications satellites. The accuracy with which these payloads were injected into the transfer paths was such that considerably less fuel than anticipated was needed to move them into their final positions, leaving a much greater reserve in hand for stationkeeping manoeuvres.

Such unexpected injection accuracy has been a gratifying discovery for the Shuttle community, since there had been concern that the precision attainable (at least initially) might be much less than with throw-away rockets. As a result, NASA has been able to tighten up its launch guarantees, enhancing the Shuttle's value over the competing expendable rockets. The payoff is considerable. Lt. Gen. James Abrahamson, head of the Shuttle programme, is reported as observing that the business satellite launched on Mission 5 may have as much as two years' additional lifetime as a result of the fuel savings achieved.



MISSIONS TO SALYUT

By Phillip Clark

The Soviet space programme is still a closed book to most of us in the West, with no advanced notice of manned missions. We asked Phillip Clark to attempt to predict the manned flights for this year; he has already been proved to be remarkably accurate. The text below was written well before the Soyuz T–10 launch on 8 February with cosmonauts Kizim, Solovyov, and new-man Oleg Atkov aboard.

Introduction

It is difficult to predict the events of the Salyut 7/ Soyuz T programme but we can make educated forecasts for this year's flights. The basic Soyuz landing windows (taken from Ref. 1) can be used; the diagram shows them for 1984. Salyut's manoeuvres will tend to change these dates but we should be roughly correct. The diagram follows the style for the 1982 and 1983 missions to Salyut 7 [2], the five-day long [3] landing window opens when Salyut is passing over the normal landing site at local sunset.

Assumptions for 1984

While the basic landing opportunities can be clearly defined, launches can be made generally on any date. It is only when the flight lifetime is known or estimated that we can fix a launch date. For 1984, we can assume:

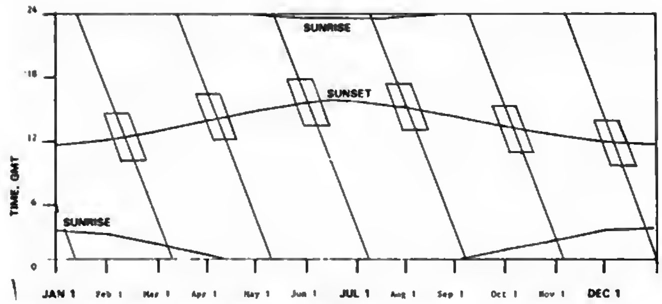
1. An attempt will be made to break the 211-day manned flight record. To do this officially, the old record must be exceeded by at least 10%.
2. Two eight-day "visiting crew" missions will be flown to the "resident crew."
3. Towards the end of the main mission, a new resident crew will be launched to take over operations on Salyut 7.

We also *know* that a Soviet-Indian manned mission lasting for eight days is due in April.

From the diagram, the landing opportunities begin on the following dates: 10 February, 7 April, 3 June, 3 August, 6 October and 8 December. These dates are not exact, since Salyut's manoeuvres will alter them slightly. Also, the Soyuz T–7 (1982) and Soyuz T–9 (1983) missions ended some weeks before the expected landing opportunities.

Missions in 1984

1. Soyuz T-10, launched about 10 February with a three-man resident crew for Salyut 7, docking at the front port.
2. Progress 19 will follow soon on an unmanned resupply mission, using the rear Salyut port. Lifetime about four weeks.
3. Soyuz T-11, launched about 1 April with the Soviet-Indian crew. Docks at the rear port and returns after eight days.
4. Progress 20, as Progress 19.
5. Soyuz T-12, launched 27 May with two men and a woman. Docks at the rear port. The crew return in Soyuz T–10 after eight days (Soyuz T lifetime 115 days).
6. After the T-10 recovery, a new Cosmos "Star" module could be launched, docking at the front in mid-June, undocking in late August. The Cosmos landing capsule could be returned during the early August landing window (while the main craft is still attached to Salyut) or remain in orbit until the October landing window.
7. At this point, T–12 could undock from the rear of Salyut and re-dock at the front.
8. Soyuz T-13 could be launched on about 15 September with the next (three-man ?) resident crew. The aborted Soyuz T launch in 1983 suggested a three-four week period with the two cosmonaut teams on Salyut.
9. Soyuz T–12 recovered about 7 October, with the original T–10 cosmonauts: spacecraft lifetime, 133 days - crew duration 240 days.
10. Soyuz T-13 crew begin a new cycle......



Launch and landing times to Salyut 7 in 1984. The times of sunrise and sunset (converted to GMT) are shown for the mean Soyuz landing site. The sloping lines represent the times of launching and landing for rendezvous missions during the year. In recent years, landings have come on the same line as launches. A landing "window" begins when the launch/landing line crosses the sunset line, and lasts for about five days.

Crews for 1984

The men known to be training for Salyut resident crew missions are L.D. Kizim, V.A. Solovyov, A.A. Serebrov, V.G. Titov, G.M. Strekalov and Volkov - the latter being a rumoured new cosmonaut. In addition, there will be a number of as-yet unidentified men in this group. The crews for the short Indian mission have already been announced. Finally, the Soyuz T–7 back-up crew of Y.V. Romanenko, V.P. Savinykh and a woman known only as "Irena" at present may still be in training for a short mission, plus a back-up crew for any projected mission (in 1982 it was learned that a group of women cosmonauts was in training, other than Savitskaya and her back-up [4]). The crews for the 1984 missions could therefore be:

T-10 Kizim, Solovyov, Serebrov (?)
T-11 Malyshev, Rukavishnikov, Sharma, back-ups Berezovoi, Grechko, Malhotra (Indian crew, as announced)
T-12 Romanenko, Savinykh, "Irena"
T-13 Titov (?), Strekalov (?), Volkov (?)

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1. P.S. Clark, "Soyuz Missions to Salyut Stations," *Spaceflight*, 259-263 (1979).
2. P.S. Clark, "The Soviet Space Year of 1983," *JBIS*, submitted for publication.
3. V.D. Blagov, "Cosmic Marathon," *Zemlya i Vcelenniya*, 1983, issue 5, 12-13. (Copy and translation, courtesy Jonathan McDowell).
4. Private communication, January 1983.

Further news: Progress 19 was launched on 21 February and docked with Salyut 7 on the 23rd. *-Ed*

THE FIRST FLIGHT OF SPACELAB

By John A. Pfannerstill

The ninth Space Shuttle mission marked the first flight of the European Space Agency's Spacelab into space. Years of effort had gone into this cooperative project to prove the concept finally in the space environment. The flight was a resounding success, paving the way for next November's Spacelab 3.

Introduction

Originally scheduled for 30 September, various technical and equipment problems pushed the launch of STS-9 back to 28 November.

The main objective was to test the entire Spacelab system. This involved evaluation not only of the hardware and experiment support equipment, but also data transmission to Earth, ground support procedures and flight crew work.

A total of 72 experiments were flown, covering the five disciplines of astronomy, solar physics, materials processing, atmospheric physics and Earth studies and life sciences. These experiments provided a rigorous test of Spacelab's usefulness in the various fields of space research, while supplying valuable scientific data as a bonus.

One exciting aspect was that, for the first time in history, non-astronaut scientists were to go into space to perform experiments themselves. For Spacelab 1, two "Payload Specialists" were named from a pool of candidate scientists chosen by the experiment investigators. Dr. Ulf Merbold of the Max Planck Institute for Metals Research in Stuttgart, West Germany represented ESA, and Dr. Byron Lichtenberg of the Massachusetts Institute of Technology was selected on behalf of NASA. Although Spacelab itself was funded entirely by ESA, both NASA and ESA contributed equal financial resources to the first mission's science payload and thus one PS was chosen for each agency.

Accompanying the two scientists was a standard crew of four NASA astronauts. Mission commander John Young led the team of Pilot Brewster Shaw and Mission Specialists Owen Garriott and Robert Parker. Both Shaw and Parker were making their first space flights, but Young and Garriott were veterans. Between them, they had six flights and over 80 days of space experience. The six-man crew was the largest single team ever to leave a launch pad. In addition, Merbold became the first non-American to fly on a US mission.

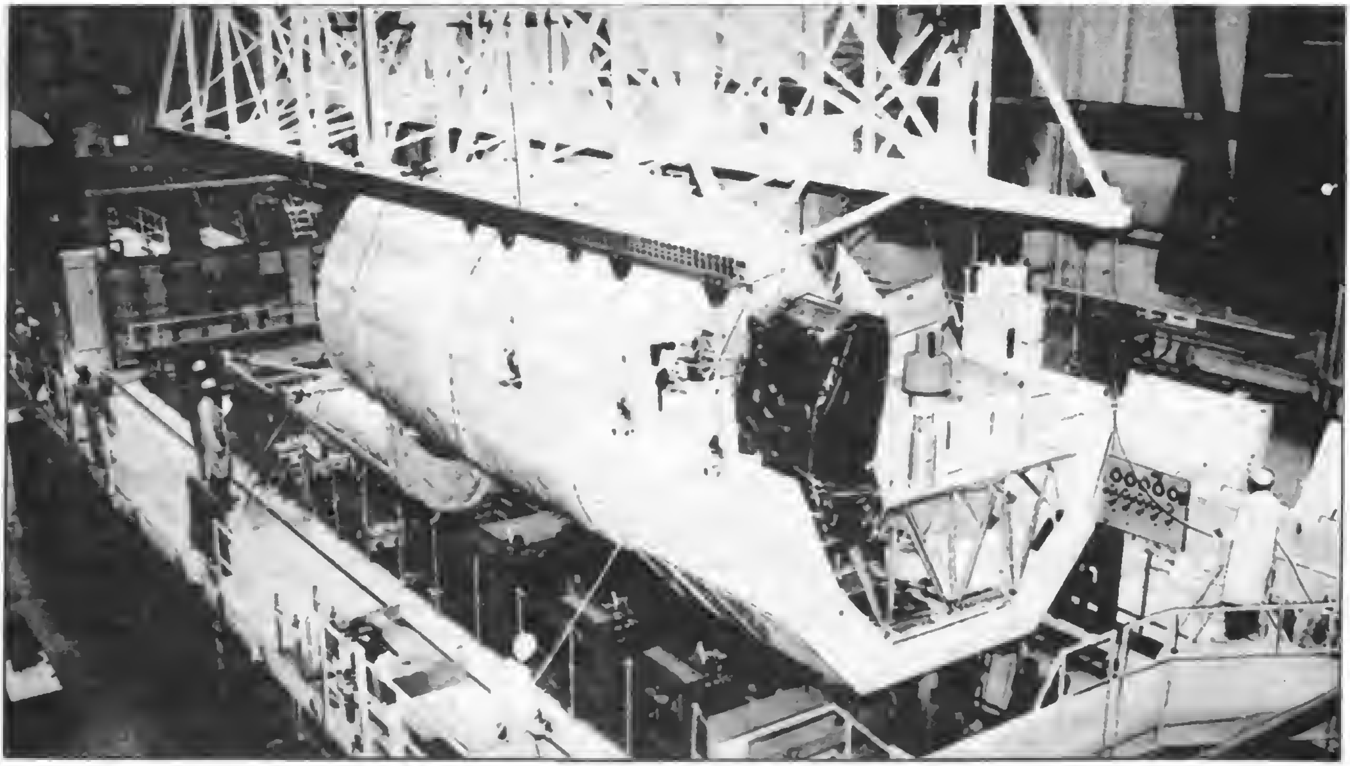
Launch Day: 28 November 1983

After some initial fears about an approaching weather front, Shuttle *Columbia* took to the air right on time at 16:00:00.84 GMT (all times in this report are GMT unless otherwise noted). It was the veteran Orbiter's sixth mission and its first since STS-5 more than a year earlier.

In order to reach the high-inclination 57° orbit for the mission, the Shuttle had to head north-easterly out of the Kennedy Space Center instead of the usual due east as on most 28.5° inclination missions. This unique path took the crew up the US eastern seaboard, over Newfoundland, the UK, Germany, Poland and the western USSR; all within half an hour of launch. Controllers in the Mission Control Center-Houston (MCC-H) monitored the ascent more carefully than usual, because, in the event of a problem - such as the loss of a main engine - there was a possibility that the External Tank could fall on densely populated areas of Europe. But the concerns proved groundless. *Columbia* attained a perfect 250 km circular orbit following a textbook ascent and two on-target Orbital Manoeuvring System (OMS) insertion burns. The ET fell, as planned, into the Indian Ocean.

As soon as the payload bay doors were opened and MCC-H gave the crew 'GO' to stay on-orbit, work began on entering Spacelab. The lab module had been kept pressurised during launch, but with the hatches at each end of the 5.8 m access tunnel closed. For a time it seemed that the hatch on the Orbiter middeck end of the tunnel had been sealed too well - the astronauts had trouble opening it. TV views showed all six men tugging

Launch day breakfast. From left: Merbold, Parker, Young, Shaw, Lichtenberg and Garriott. *NASA*



The complete laboratory with, at left, the transfer tunnel attached. *All illustrations NASA*

and pulling on its latch mechanism at one time or another. It finally popped open and Garriott, Lichtenberg and Merbold floated into the 7 m long Spacelab module at 19:42.

A TV camera on the lab's far wall showed the three of them shaking hands and slapping one another on the back in congratulations. They gleefully turned weightless somersaults in the spacious chamber and remarked on the excellent shape of everything. "It looks like Spacelab came through with flying colours," Lichtenberg said.

An aim of Spacelab 1 was to test crew work routines. For this mission, NASA and ESA wanted to try out 24-hour-a-day scientific research to see how well it would work. If the off-duty crewmen were able to sleep while the others were at work, the round-the-clock schedule might be used on future missions.

It now seems that crews of *eight* will become standard on Spacelab flights.

Thus, with Spacelab open for business, it was time to split the crew into their two 12-hour duty shifts. Young, Parker and Merbold made up the "Red" team, while the rest comprised the "Blue." Although the schedule varied slightly from day to day, the Reds were on duty roughly between 02:00 and 14:00.

The six-man crew was split so that each shift had at least one member with space experience. In addition, the split ensured that one pilot, one mission specialist and one payload specialist would be on each shift. The plan was to have the pilot astronaut stay on the flight deck to monitor systems and control spacecraft attitude, while the other two performed the scientific work in Spacelab itself.

MCC-H even changed its mode of operation for Spacelab in that two separate control rooms were used. The familiar Mission Operations Control Room (MOCR) in Building 30 at the Johnson Space Center was the main control centre and had the responsibility for running the Orbiter-end of the operation and keeping its systems under watch. Astronaut capcoms in this room spoke mainly to pilots Young and Shaw about matters related to *Columbia* itself. In a smaller room in Building 30,

NEW SPACELAB MISSION

The late Spacelab launch (late November instead of September) meant that some of the experiments suffered because of changes in the Sun's lighting angles. NASA has now scheduled a mission called EOM 1 (Environmental Observation Mission 1) for June next year to refly some of the equipment to obtain better results.

Swiss astronaut and BIS Fellow Claude Nicollier has already been chosen to act as a Mission Specialist for the flight. He was originally chosen to train as a Payload Specialist for Spacelab 1 but then switched to become a full-time astronaut. The other crew members will possibly be chosen from the existing Spacelab 1 team because there is so little time to train new Payload Specialists afresh.

NASA had previously announced 41 Spacelab missions to the end of September 1988, although only five of these are to carry the habitable modules. Fiscal Year 1984 (ends September) will see three Spacelab pallet flights, while FY 1985 was to have had four pallet-only flights and two pallet-module missions. These two latter are the life sciences Spacelab 3 this November and the material processing German D–1 in September 1985. Now the 51H/EOM–1 mission launched on 10 June 1985 will have some Spacelab 1 experiments. Spacelab 2 next March will not carry the habitable module.

In FY 1986 Spacelab 4 will use a module in January 1986 and six other Shuttles will use pallets only. May 1987 will see Spacelab 8 with a module, while 12 other missions have pallets for FY 1987. The following year will see 11 pallet flights and one module - the latter being the Japanese-sponsored flight, or Spacelab J.

NASA's new price-structure for Shuttle mission will charge $82 million for a Spacelab 1 type of configuration and $42 million for two pallets and an igloo (a small pressurised unit for housing delicate equipment in the cargo bay).

SPACELAB 1: THE SCIENCE

Spacelab 1 was a multi-disciplinary mission of more than 70 experiments in five areas: Astronomy and Solar Physics; Space Plasma Physics; Atmospheric Physics and Earth Observations; Life Sciences and Materials Science.

There were 38 different experiment facilities. Sixteen of the 38 experiments were placed on the pallet and 20 in the module (two use both). Nearly 60 were sponsored by ESA.

The experiments were selected from more than 400 proposals solicited by NASA and ESA in 1976. An international panel selected them for flight based on their scientific merit and suitability for flight on the Shuttle/ Spacelab. The principal investigators, or chief scientists for each experiment, formed a cooperative body called the Investigators Working Group (IWG), consisting of 35 of the lead scientists from all five disciplines. The group guided the incorporation of the experiments into a single payload and served to coordinate the needs of the user scientists to the Mission Manager.

Astronomy and Solar Physics

The astronomy and solar physics investigations studied astronomical sources of radiation in the ultraviolet and X-ray wavelengths, performing both surveys and detailed studies of specific objects. The solar experiments measured the energy output of the Sun, using three different methods with a view to quantitiative measurement of variations in its value (the so-called solar constant).

Space Plama Physics

The five experiments measured the magnetised and electrified gas ('plasma') in the Earth's upper atmosphere (ionosphere).

These experiments studied the plasma envelope surrounding the Earth and investigated key relationships between the Earth's magnetosphere and atmosphere.

Some involved emitting beams of charged particles into space and measuring the resultant changes in the environment. Others created artificial aurorae to help explain how natural particle beams carry energy from the solar wind and the magnetosphere into the atmosphere. TV cameras, sensors and optical instruments monitored natural processes as well as the effects of the emitted beam experiments.

Atmospheric Physics and Earth Observations

The atmospheric physics investigators performed studies of the Earth's environment through surveys of temperature, composition and motion of the atmosphere. These investigations used remote sensing and imaging techniques to study the emissions and absorptions from atmospheric gases to determine their sources, flow patterns and decay mechanisms.

The Earth observations experiments demonstrated advanced measuring systems which will be used on future Spacelab missions. There were six atmospheric physics and Earth observations experiments on this Spacelab.

A large film metric camera produced high-resolution photographs (about 1000) for possible use in making better maps. The late launch meant poor Sun angles in the northern hemisphere. A microwave remote sensing facility was to have provided all-weather radar viewing of the Earth's surface, regardless of cloud cover, but a power failure meant that it could be used only as a passive sensor of thermal radiation.

Life Sciences

The 16 life sciences investigations were concerned with the effects of the space environment (microgravity and hard radiation) on human physiology and on the growth of biological systems. Two experiments studied the effects of direct exposure to space on biological materials.

In this low-gravity environment a special category of experiments probed the interaction between man's vestibular system and the brain, with a view to understanding the causes of space motion sickness (Space Adaptation Syndrome) and providing information that can be used in more general aspects of vestibular research on Earth.

Another set assessed the effects of radiation and weightlessness on other organisms. In particular, scientists were interested in possible disturbances of cell growth. New "mapping" techniques were used to measure the level of space radiation penetrating the wall of the module.

Bacteria and other microbes were examined after the flight to determine the biological hazards of exposure to ambient ultraviolet and cosmic radiation. Observations of sunflower seedlings and fungi growing yielded new information on plant growth patterns normally influenced by gravity and 24-hour circadian rhythms.

Materials Sciences

The 36 material sciences experiments tested low-gravity techniques for processing materials. They took advantage of microgravity to perform studies in such areas as tribology, fluid physics, crystal growth and metallurgy.

A Material Sciences Double Rack facility was carried with furnaces and equipment shared by investigators from 10 European countries. Most of the experiments used the facility for studies of crystal growth, fluid physics, chemistry and metallurgy. More than 80% of the work was completed, with a large silicon crystal being produced in space for the first time.

however, was the Payload Operations Control Center (POCC), which controlled and monitored the scientific work going on aboard Spacelab. From this room, a Crew Interface Coordinator (CIC) spoke to the science crew-members about research-related items. Backup payload specialists Wubbo Ockels and Michael Lampton served as CIC for the Red and Blue shifts respectively, but the system was flexible and often the principal investigators themselves got on the air-to-ground loop from the POCC to talk to the astronauts.

The Blue team drew the first shift. While the Reds settled down to sleep in the Orbiter middeck, the Blues had the responsibility for powering up Spacelab, checking its systems and conducting its first experiments.

The experiment with the honour of being the first to be activated was 1ES031 "Effect of Weightlessness on Lympohcyte Proliferation" which was an ESA experiment aimed at determining how zero-g affects the human body's immune response system. Most of the experiments of the first few days investigated changes in the human body during early adaptation to zero-g in an effort to determine why some 40 per cent of all space travellers become sick during this period.

Garriott and Lichtenberg performed some six experiments during their first duty cycle before turning things over to the Reds shortly after 04:30 on 29 November, beginning the second day.

Mission Day 2: 29 November 1983

When Young, Parker and Merbold came on duty for their first shift, they soon had a problem. An electronic component called a Remote Acquisition Unit (RAU) failed. There were a dozen RAUs on the Spacelab exterior pallet; their job was to handle communications between the Spacelab computer and the pallet experiments. This particular RAU handled low-priority housekeeping data for two instruments but, more critically, it also handled hard science data from two others. Changing the software got the baulky unit operating for about an hour or so before it went down a second time. It remained unusable until early on Day 3 when it mysteriously started working again.

Meanwhile, the astronauts on both shifts performed more life sciences experiments. The "Drop and Shock" and "Rotating Dome" portions of the 1NS102 Vestibular Investigation were performed as well as blood sample collection from all four science crew members.

NASA reported that some 21 experiments had been started by the end of Spacelab's first 24 hours. The schedule was hectic and the controllers in the POCC acknowledged they were pushing the spacemen fairly hard. At times, the astronauts found that activities had been scheduled too close together. "You can't do everything in instant time around here," one of them lamented at one point. The over-tight scheduling recurred later in the mission.

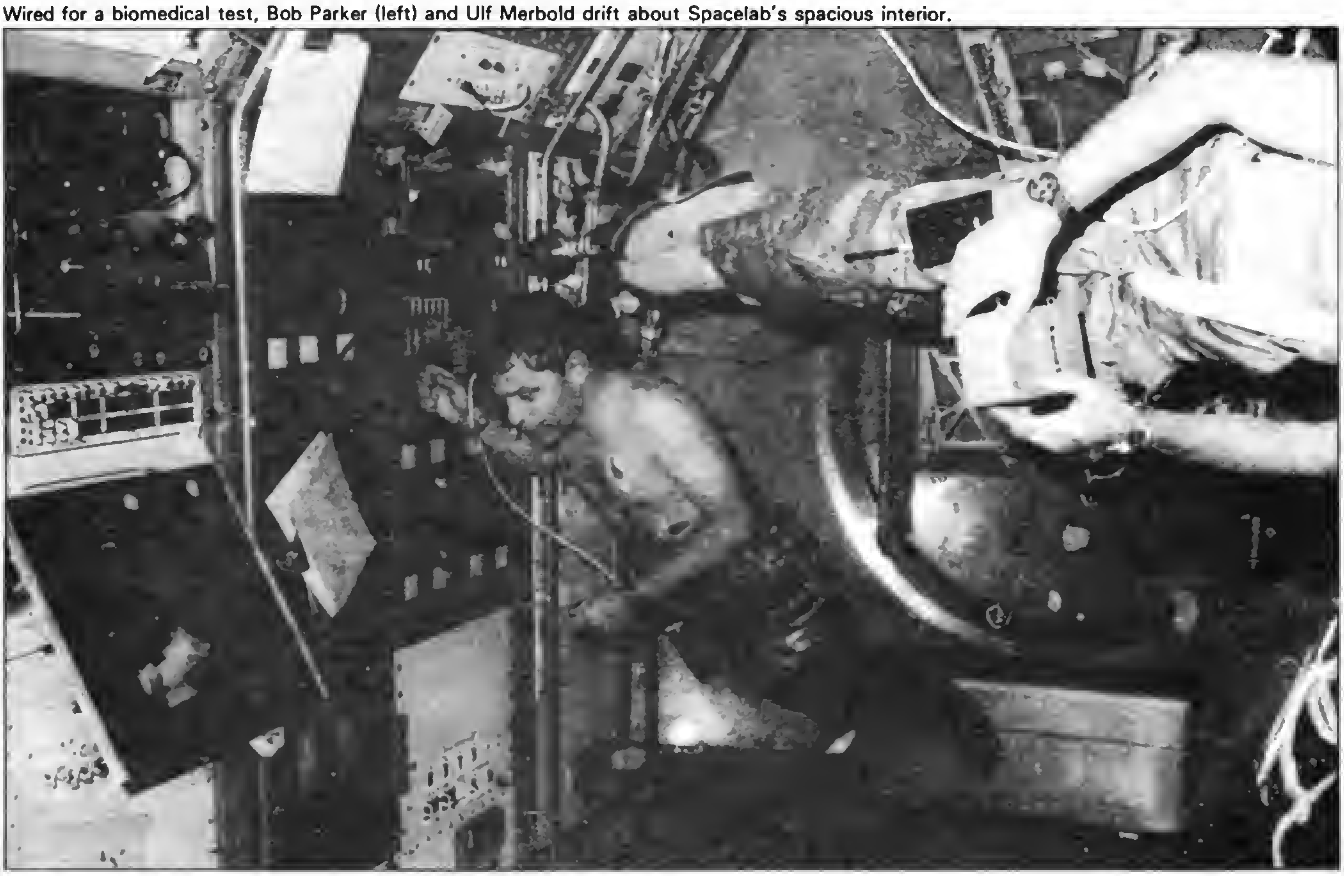
Mission Day 3: 30 November 1983

Day 3 marked the winding-down of most of the early zero-g adaptation medical experiments. For one of the final tests Parker was strapped into a seat while warm air was blown into his right ear and cooler air into his left. A TV camera recorded the motions of his left eye in relation to the air blasts. A large image of his blinking eye filled TV screens in the POCC as CIC Wubbo Ockels urged Parker on: "Eyes open Bob, don't go to sleep up there!" Parker obeyed, dutifully keeping wide-eyed for the German-sponsored ESA vestibular experiment designed to test how the eyes react to ear stimuli.

The crewmen then began work in earnest in other fields. Materials processing was started using Spacelab's large double-rack furnace facility, photographs of the Earth were taken with the ESA-sponsored German mapping camera and some astronomy and atmospheric physics investigations were begun.

On Day 3, Garriott also began making the first-ever

Wired for a biomedical test, Bob Parker (left) and Ulf Merbold drift about Spacelab's spacious interior.



amateur radio contacts from space. Using his W5LFL call sign and a small two-watt transceiver, he transmitted continuously on even-numbered minutes during his free periods, allowing ground-based radio 'hams' to call him on odd minutes, thereby establishing two-way contact with as many people as possible. A long-time amateur radio enthusiast, Garriott and some other members of the American Radio Relay League set up the exercise after receiving special permission from NASA. Garriott planned to "work" the 2 m band almost daily during the flight. His persistence paid off. During one pass over the Middle East the astronaut made contact with another famous amateur radio buff: King Hussein of Jordan.

Mission Day 4: 1 December 1983

The fourth day featured a considerable effort on both shifts using the 1NS002 Space Experiments with Particle Accelerators (SEPAC) equipment. The Japanese-built electron gun was designed to create artificial aurorae which could then be studied to gain understanding into how natural aurorae form. Garriott said that the beam from the SEPAC generator was so bright that he suspected that it would probably be easily visible from the ground. He compared it to an airport beacon light in intensity.

Events were still moving rapidly. Most experiments were taking longer than planned and the crewmen became edgy and irritable at times. During the Red shift things came to a head.

Parker was busy setting up for a life science experiment he was intending to run on Merbold when CIC Ockels started giving him instruction about charging the SEPAC battery - an activity not scheduled for that time. Parker's biting words in the following exchange clearly took the Dutch astronomer by surprise:

Parker: If you guys would recognise that there's two people up here trying to get all your stuff done, I think you might be quiet until we get one or the other of them done.

Ockels: Well, that's true Bob. However, we thought you were waiting for Ku-band acquisition at the moment and the battery...

Parker: (cutting in) Just wait! Would you guys please tell us exactly what you want done when and we'll forget about what else we're doing at the present time. Do you want us to get Ulf out of the seat and we'll go do all these things?

Ockels: Negative Bob. We want you now to...

Spacelab 1, nestled snugly in the payload bay of *Columbia*.


The entire STS-9 team gathers for a group portrait in one end of Spacelab. Clock-wise from top, they are, Brewster Shaw, Owen Garriott, Ulf Merbold, John Young, Robert Parker and Byron Lichtenberg.

Parker: (cutting in again) Please hang on!

And with that, the case was closed.

In a later TV press conference with journalists in Houston, Parker shrugged off the incident. Clearly, it had not been a personal attack on Wubbo Ockels. The incident simply demonstrated that, like any job on Earth, even in space there were times when the boss demanded more than an overworked employee could produce.

Also on Day 4, flight director Charles Lewis disclosed that, owing to a lower than expected fuel cell reactant usage rate, controllers were considering adding an extra day to the mission. No firm decision was to be taken yet. Much would depend on the weather forecasts for Edwards Air Force Base as the landing came closer.

Mission Day 5: 2 December 1983

During Day 5, Spacelab suffered a major blow. The lab's high-speed data recorder malfunctioned, causing problems on two counts:

1. Valuable science data were being lost every moment the recorder was down because a much slower backup recording method had to be used. The backup could handle only 1/30th as much as the main recorder.
2. Valuable time was being lost from the already over-booked experiment schedule as the astronauts tinkered with the faulty unit. The troubleshooting eventually paid off when Parker and Merbold got the recorder back into service using little more than a screwdriver.

Quite a bit of onboard TV was transmitted during the day including spectacular views of the Earth with Spacelab and the Orbiter's tail in the foreground, views of night-time lightning bursts and the first scenes from *Columbia*'s flight deck. Up to that point, all on-board TV had been from either the lab module or the Orbiter middeck. Brewster Shaw was seen at the controls of *Columbia*, making his first TV appearance. Both he and commander John Young had been maintaining a low profile during the flight, faithfully manoeuvring the Orbiter as required by the various experiments. Very little was heard from either of them, which also was an indication of *Columbia*'s troublefree performance.

Mission Day 6: 3 December 1983

Day 6 was filled with more problems and trouble-shooting. This time, two furnaces in the materials science Double Rack facility went down in addition to the German Earth mapping camera. The problem with the camera appeared to be a film jam, while the problems with the Isothermal Heating Facility and the Mirror Heating Facility were harder to identify. The crew spent considerable time trying to get them back into operation but, in the final analysis, scientists in the POCC decided that the three pieces of equipment were probably out of commission for the rest of the flight.

The troubleshooting put the astronauts further behind schedule, and that may have been a factor that led MCC–H to announce an additional flight day. This would give the tired, overworked crewmembers a chance to "tie up some loose ends."

Mission Day 7: 4 December 1983

The astronauts, for their part, were not willing to give up so easily on the malfunctioning equipment. Parker and Merbold stuck at the repair work and managed to get some results. A small re-wiring job was all that was needed for Merbold to get the MHF back into operation,

after which he reported to the POCC that it was "really in great shape."

Parker, meanwhile, took the jammed mapping camera into *Columbia*'s middeck where he turned out all the lights after putting the camera inside a sleeping bag. With everything thus light-protected he opened up the camera and unjammed the film magazine with his fingers.

Mission Day 8: 5 December 1983

The big event of Day 8 was an international press conference involving thousands of miles of cable, five satellites and journalists in six European capitals.

The conference was opened by statements from US President Ronald Reagan from the White House in Washington, DC and West German Chancellor Helmut Kohl in Athens.

Much to NASA's dismay, only astronaut John Young and the two payload specialists, Byron Lichtenberg and Ulf Merbold were permitted to participate in the press conference. A detailed script submitted by the White House was transmitted up to *Columbia* in advance so that the three crewmembers would know exactly what to say and when to say it. For their part, the three banished astronauts staged a protest of their own in the form of a "hear no evil, see no evil, speak no evil" monkey act during a pre-conference test of the TV system. Garriott covered his eyes, Parker his ears and Shaw his mouth. Although their dissent failed to change anything, the men succeeded in making their point.

Mission Day 9: 6 December 1983

With the end of the mission rapidly approaching, NASA meteorologists began keeping a close eye on the weather forecasts for Edwards Air Force Base. For a time, it looked like MCC-H might have to take back the extra flight day. A weather front appeared to be heading toward southern California, and there was a possibility that *Columbia* might be brought back to Earth on 7 December as originally planned in order to beat the weather. But later in the day, when the forecast improved, a firm decision was made to keep the one-day extension.

Meanwhile, *Columbia's* orbital precession rate was carrying it into a path which kept it roughly Sun-synchronous over the terminator, putting the Orbiter in continuous sunlight. The Spacelab researchers took advantage of this to conduct many of the solar astronomy experiments. The design engineers used the situation to do some thermal testing on the Spacelab system, keeping the payload bay always facing the Sun to see how well the lab's heat rejection systems would work under such severe conditions. The astronauts reported that the spacecraft was creaking and groaning, presumably due to the expansion of metal. The men also went shirtless much of the time because the lab module's interior was much warmer than usual.

Mission Day 10: 7 December 1983

The last full day in space was more relaxed. Mission planners gave the men the opportunity to do whatever they felt like. Most of the time was spent looking out of the windows, taking pictures of anything that happened to catch their fancy.

During a TV pass over the northwestern US Lichtenberg provided a commentary on the beautiful views of the snow-capped mountains in Washington state. It was one of the few chances he had had to sightsee during the entire flight up to that point.

The astronauts did have to start packing up to come home, however, and Young and Shaw had to check *Columbia* out to make sure it was ready for the landing.

Part of the Spacelab crew visited the UK in early February to discuss the mission's preliminary results with a wide audience of European scientists. *Spaceflight* editor Andrew Wilson attended the seminar at the Royal Society to hear Owen Garriott (pictured above), Byron Lichtenberg, Ulf Merbold, Brewster Shaw and Wubbo Ockels describe the mission. The short film presented there will also be screened at a BIS meeting on 30 May when Dr. D. Shapland of ESA will talk about the flight

Everything came through with flying colours, including the weather, and the Orbiter was set to return to Earth at 15:58 on 8 December after the longest Shuttle flight thus far.

Mission Day 11: 8 December 1983

Things were proceeding smoothly towards *Columbia*'s planned touchdown at Edwards Air Force Base when a major problem stopped everthing. At about 10:15, Young and Shaw commanded one of the Orbiter's upward-firing Reaction Control System (RCS) jets in the nose to fire. The jolt from the 3,870 N thrust engine was much harder than any of the astronauts had ever felt before and, at the same instant, one of *Columbia*'s four redundant General Purpose Computers (GPC No. 1 in this case) failed. Five minutes later, during another thruster firing, GPC-2 also failed.

After about 40 minutes, Young and Shaw were able to bring GPC-2 back on line but, despite all efforts, GPC-1 remained down. Young and Shaw both felt certain the failures had been caused by the abnormally hard thruster shocks but no-one really knew what had happened and, as a result, MCC-H flight controllers decided to delay the entry until a better understanding could be gained.

There were two more de-orbit opportunities for an Edwards landing on 8 December. The first was on Orbit 165, resulting in a landing at 22:17 and the second was on the next pass after that, giving a touchdown time of 23:47. This meant anywhere from a six to an eight-hour delay. Young opted for the later of the two times because he had been up nearly all night and the Orbit 166 deorbit would give him a chance for a nap.

While engineers on the ground were trying to work out the GPC problem another failure occurred, this time knocking out one of *Columbia*'s three Inertial Measure-

ment Units (IMUs). The IMUs provide the Orbiter with a stable navigational reference and are crucial to the reentry. But, like the GPCs, the IMUs are redundant and a successful descent and landing could be made with only one of the three units in operation.

Hours of study at MCC–H seemed to indicate that the GPC failures were caused by a "transient" hardware problem. After much discussion, *Columbia* and her crew were cleared for the Orbit 166 landing opportunity.

About an hour before the planned touchdown time, while over the Indian Ocean, the two OMS engines were burned for 156 seconds to nudge *Columbia* out of orbit. The manoeuvre was right on target and the craft headed northward on its reentry path on a track taking it over eastern China, the Kamchatka Peninsula, the Aleutian Islands, the Gulf of Alaska and finally down past San Francisco and the middle of California to Edwards.

The Orbiter arrived at the Air Force base just before sunset. Beautiful weather greeted her as two T–38 chase aircraft joined up, sending back striking TV coverage of the approach.

As she had on five previous occasions, *Columbia* swooped down to a textbook landing. Under the expert hand of NASA's most experienced astronaut, the main landing gear wheels touched the lakebed runway 17 at exactly 23:47:23, ending the longest Shuttle flight to date with a flight time of 10 d 7 h 47 m 23 s.

Moments later, as Young lowered *Columbia*'s nose gear to the ground, GPC–2 again dropped off the line, lending credence to the pilots' theory that the previous computer failures had been due to shock.

A full minute after landing, *Columbia* had completed its rollout and was stopped on the runway awaiting the customary parade of convoy and rescue vehicles. The recovery team had the six-man crew out of the spacecraft just 31 minutes after touchdown.

Young and Shaw were able to go immediately back to Houston to a reunion with their families and friends. Parker, Garriott, Merbold and Lichtenberg had to stay at Edwards for an additional week, however. This was so that they could undergo more testing as part of the scientific programme to gather data on how their bodies re-adapted to one–g after the flight.

Aftermath

During a post-mission inspection of *Columbia*, engineers were startled to discover evidence of a fire in the form of charred wires and equipment in the aft section. The source of the blaze was traced to leaking hydrazine from two of the three Auxilliary Power Units (APUs) which apparently caught fire some 2 to 2½ minutes before landing. The astronauts were not aware of the fire, which continued until several minutes after touchdown. The only abnormal indication they had was when one of the affected APUs shut down about four minutes after the landing.

NASA was, of course, alarmed about the situation and many people were haunted by the chilling thought of what might have happened had all three APUs been knocked out by a fire earlier in the descent. The units control aerosurface operation and without them *Columbia* could have plunged to the desert floor like a fatally wounded goose - her crew having no means of escape.

Fortunately, this had not happened, but in order to understand the problem fully, NASA decided to delay further missions until the reason for the fire was fully understood and the problem corrected. The solution proved to be simple. Rubber "O" rings in the hydrazine lines were found to have deteriorated, causing the highly inflammable fuel to leak out and catch fire because of the high APU operating temperature. From now on, technicians would check the rings after each flight and replace them if necessary.

Other than the major problems of the fire, the GPC and IMU failures, however, *Columbia* came through in fine shape. Her next stop after returning to Kennedy for Spacelab offloading was the Rockwell International plant in Downey, California where the veteran Orbiter would receive a complete factory overhaul before her next scheduled flight in August 1984.

The Brighton Pavilion will be included on a special Ladies' Programme being organised for Space '84.

The Society will once more be using Brighton as its Space venue because of the excellent Conference facilities. Brighton has been on its toes to cater for conference business for many years now and has grown to one of Europe's largest centres during the past decade. Our venue, The Brighton Centre, opened in 1977. It is a multi-purpose building packed with specialist features which make it indispensible for large meetings such as Space '84. We will be using the Foyer Hall, as for Space '82, which everyone found so satisfactory and with the huge Main Hall, once again, reserved for the Banquet.

The Foyer Hall seats up to 800 people although we want to keep numbers down to about half that, so that everyone has plenty of room (plus exhibits, etc.). The Main Hall – if we needed it at some future time – provides a 5000 seat capacity with translation and TV/radio facilities also available and with many smaller 'seminar' rooms to hand.

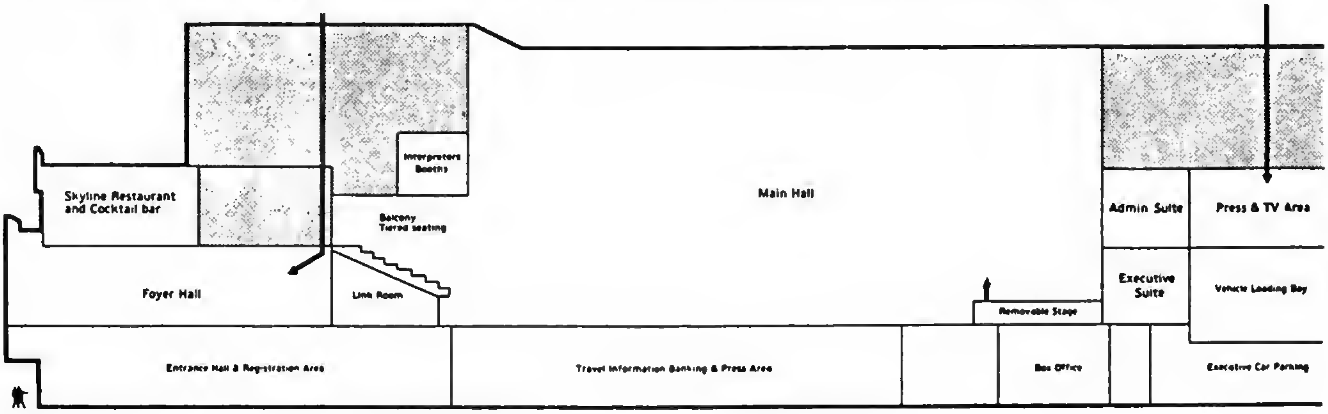
Brighton is easy to reach. Gatwick airport – with links to 125 cities around the world – is only 30 minutes away, with the M23 connecting to Brighton on one hand and London on the other. Accommodation, ample and varied, ranges from the small guest houses to the first class hotels. A large selection of theatres, restaurants and clubs ensures there is plenty of night-time activity.

There is always plenty to see during the breaks at Space '84. The most famous of all Brighton's attractions is surely the Royal Pavilion, completed in 1822 by the Prince Regent. This is one of the stops of the Space '84 ladies programme (more details will be available later). Just a minute's walk away are the 'Lanes,' in the traditional heart of Old Brighton. Theses are a tangle of small by-ways filled with antique shops, pubs and restaurants.

16-18 November 1984

SPACE '84

Below: A schematic of the Brighton Centre. The dimensions have been distorted to squeeze several floors on to one diagram.



THE SHUTTLE INFRARED TELESCOPE

By John Bird

The success of the IRAS astronomical satellite has whetted the astronomers' appetites for future infrared observations from orbit. The author describes a project being planned to use the Shuttle as a flying observatory.

Introduction

With the success of the Infrared Astronomy Satellite, astronomers are now looking forward to the next step: the Shuttle Infrared Telescope Facility (SIRTF). Carried in the Shuttle cargo bay, its first flight is planned for 1990. Compared to IRAS, it will be able to see shorter and longer wavelengths, thus providing a more comprehensive view of the infrared Universe.

The mission concept and feasibility studies have been completed and preliminary instrument design and mission definition work will begin in April. Instrument delivery to the Kennedy Space Center will be in October 1989 for a launch the following September.

Infrared Astronomy

The objective is to observe infrared light wavelengths from 1.8 to 700 microns (1 micron = 10^{-10}m) from such sources as quasars, galactic centres (including our own), and molecular clouds between stars and planets.

Infrared light is spread over about 0.8 microns to 0.2 mm, which means it is beyond red in the spectrum and hence invisible to the human eye. All objects emit radiation and even at temperatures slightly above absolute zero (−273°C) infrared is present. Telescopes on the ground can detect only a portion of this infrared light because most of it is absorbed by water vapour in the atmosphere. However, telescopes on mountains and those carried by balloons are above much of the atmospheric water and can thus be used for infrared work. Another problem with Earth-based systems is that the atmosphere itself emits infrared. On the other hand, infrared has the advantage of being able to pass through dust, giving a view of the Universe not possible with visible light. This is because the wavelength of the radiation is greater than the size of the dust grains (these are smaller than one micron — about the same as smoke particles). They originate in stars and are ejected into the interstellar medium.

We can thus observe our own Galaxy through the dust clouds normally blocking our view. Another advantage is that all types of galaxies emit infrared light and, in fact, some objects give off most of their energy in the infrared (such as stars in the process of forming).

The Mission

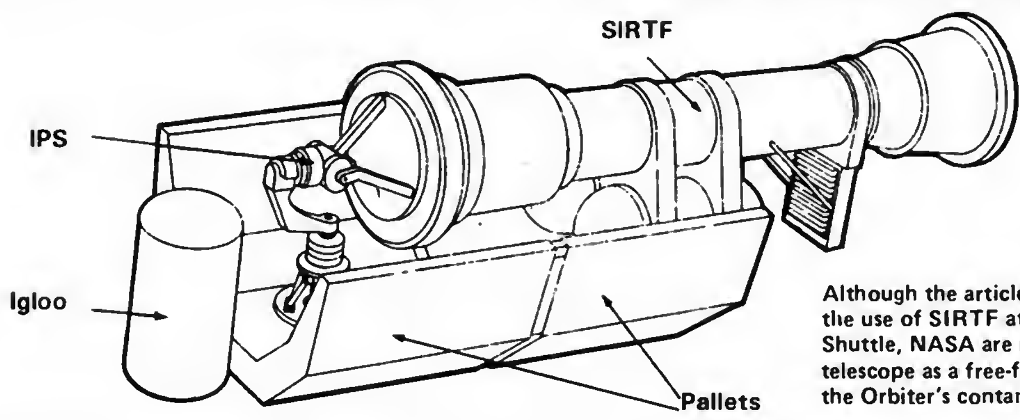
SIRTF will require a mission to itself since the telescope and related hardware will fill the cargo bay. The payload weight is 13,500 kg. The related hardware includes two Spacelab pallets, a mounting system, an Instrument Pointing System (IPS) and an Igloo. The Igloo is a pressurised cylindrical vessel used on all pallet-only Spacelab flights to provide electrical power and cooling for the pallets and associated hardware. By mounting the telescope on the IPS, itself attached to a pallet, more precise orientation is possible than with the Orbiter's thrusters. The mission will have a major advantage over the recent Spacelab 1 in that there will be only one experiment, as opposed to almost 80. This means the telescope will be used throughout the mission rather than the few hours allocated to most Spacelab 1 experiments. The flight will last 14 days, with an orbit inclined at 57 degrees, 450 km high. The orientation will be fixed for viewing astronomical objects.

SIRTF is designed for multiple Shuttle flights, eventually leading to longer duration free-flying trips in orbit. It could even be used for six months or more in conjunction with a manned space platform.

Some of the hardware details have already been defined. SIRTF will be cryogenically cooled by liquid helium, so that the telescope optics and baffles will be below 7 K (i.e. just 7 degrees above absolute zero). The normal temperature of the instrument chamber wall will be 4 K, and a 2 K heat sink will be provided. Cryogenic cooling ensures that, for wavelengths less than 100 microns, the infrared emission from the telescope itself is less than the background light of the sky.

For the early flights only two instruments will be carried in the focal plane (where the radiation is focussed) but eventually this will be increased to six. All will be housed in the "Multiple Instrument Chamber." One is a "High Sensitivity Photometer" for energy distribution and temperature measurements. A "Short Wavelength Camera" will be used to look at wavelengths of less than 30 microns, and a "Long Wavelength Camera" with photoconductive detectors will be used from 30 to 120 microns. A "Faint Object Spectrograph" will use a rotating grating and a filter wheel.

As the IRAS observatory has shown, we can expect results that will be both surprising and valuable contributions to our understanding of the Universe.



Although the article above discusses the use of SIRTF attached to the Shuttle, NASA are now considering the telescope as a free-flyer, away from the Orbiter's contamination.

SATELLITE DIGEST -173

Robert D. Christy
Continued from the April issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

STS 9 1983-116A, 14524

Launched: 1600*, 28 Nov 1983 from the Kennedy Space Center.
Spacecraft data: Columbia carrying Spacelab on its first mission. To allow 24 hour per day operation, a two shift crew was carried: John Young (Commander), Dr. Robert Parker (mission specialists) and Dr. Ulf Merbold (West Germany, payload specialist); and 8rewster Shaw (pilot), Dr. Own Garriott (mission specialist) and Dr. 8yron Lichtenberg (payload specialist). The mission was extended by one day to 10 while in flight and the actual landing was delayed several hours because of a computer fault.
Orbit: 242 x 254 km, 89.44 min, 57.02 deg.

COSMOS 1511 1983-117A, 14530

Launched: 1345, 30 Nov 1983 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument unit and cylindrical, supplementary payload at the forward end. Length about 6 m, diameter (max) 2.4 m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered or re-entered after 44 days.
Orbit: 183 x 325 km, 89.61 min, 67.05 deg, manoeuvrable.

GORIZONT 8 1983-118A, 14532

Launched: 1351, 30 Nov 1983 from Tyuratam by D-1-E.
Spacecraft data: Cylinder with a pair of solar panels plus an aerial array at one end. Length 5 m, diameter 2 m and mass in orbit approx. 2000 kg.
Orbit: Initially a low parking one at 51.5 deg, then transferred to geosynchronous orbit above 90 deg east.

COSMOS 1512 1983-119A, 14542

Launched: 1210, 7 Dec 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1511.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 355 x 416 km, 92.31 min, 72.86 deg.

COSMOS 1513 1983-120A, 14546

Launched: 0613, 8 Dec 1983 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in a drum-shaped solar array with length and diameter both about 2 m, and mass around 700 kg.
Mission: Navigation satellite.
Orbit: 961 x 1017 km, 104.94 min, 82.94 deg.

COSMOS 1514 1983-121A, 14549

Launched: 0700, 14 Dec 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1511.
Mission: 8iological satellite carrying two monkeys, 18 rats and other specimens. Recovered after 5 days.
Orbit: 214 x259 km, 89.30 min, 82.31 deg.

COSMOS 1515 1983-122A, 14551

Launched: 1226, 15 Dec 1983 from Plesetsk by F vehicle.
Spacecraft data: Not available.
Mission: Possibly electronic reconnaissance.
Orbit: 636 x 663 km, 97.78 min, 82.53 deg.

MOLNIYA-3(22) 1983-123A, 14570

Launched: 0608, 21 Dec 1983 from Plesetsk by A-2-e.
Spacecraft data: A cylindrical body housing intrumentation; the payload is surmounted by a conical motor section. Power is provided by a 'windmill' of six solar panels. Length about 4 m, diameter 1.6 m and mass around 2000 kg.
Mission: Provision of telephone, telegraph and TV relays through the 'Orbita' system.
Orbit: Initially 618 x 40635 km, 736.06 min, 62.84 deg then manoeuvred to 618 x 39695 km, 716.92 min, 62.82 deg to ensure daily ground track repeats.

COSMOS 1516 1983-124A, 14583

Launched: 0930, 27 Dec 1983 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1511.
Mission: Military photo-reconnaissance, recovered or re-entered after six weeks.
Orbit: 196 x 276 km, 89.23 min, 64.89 deg.

COSMOS 1517 1983-125A, 14585

Launched: 0925, 27 Dec 1983 from Kapustin Yar by C-1.
Spacecraft data: Delta winged re-entry vehicle approx. 3 m long and 2 m across with mass around 1000 kg.
Mission: Re-entry and recovery test, landed in the 8lack Sea towards the end of the first orbit.
Orbit: 181 x 221 km, 88.45 min, 50.67 deg.

COSMOS 1518 1983-126A, 14587

Launched: 0330, 28 Dec 1983 from Plesetsk by A-2-e.
Spacecraft data: Possibly similar to Molniya-3(22).
Mission: Missile early warning satellite.
Orbit: Initially 584 x 39345 km, 709.18 min, 62.91 deg and later manoeuvred to 591 x 39786 km, 718.24 min, 62.94 deg to ensure daily ground track repeats.

COSMOS 1519-1521 1983-127A-C, 14590-92

Launched: 0053, 29 Dec 1983 from Tyuratam by D-1-E.
Spacecraft data: All three satellites possibly similar to Cosmos 1513.
Mission: Navigation satellites in the GLONASS system and providing experimental navigation data for ships and aircraft.
Orbit: 19015 x 19139 km, 673.64 min, 64.75 deg.

FROM THE SECRETARY'S DESK

Space '84 Souvenirs

During Space '84 we plan to put on sale the tankards which proved so popular last time, hopefully in two types i.e. those specifically commemorating Space '84 and those simply containing the Society's logo.

Deciding on souvenirs for such an event can be a real headache. One usually begins with ideas on the grand scale. In the case of Space '82, the initial concept was for a set of 50 bronze medals, one to commemorate each year of the Society from 1933 to date. A list of suggested profiles was prepared, though with some difficulty in allocating items to the war years. The idea foundered simply on cost. Perhaps a set of 50 medals is rather a tall order, even if issued in strips of five over a period, but it's still rather a nice idea which might yet be adopted.

Spectre from the Past

We were delighted to welcome Roger Grimston to HQ recently, not least because he did not arrive empty handed but brought a Spectre 1A high-pressure HTP pump for eventual display in our HQ.

Roger, a long standing Fellow, was once a member of the old de Havilland Engine team, until it was taken over by Bristol-Siddeley and then, in turn taken over by Rolls-Royce. At that point their rocket development programme just about ceased so Roger left for fields anew. He recalled that the very first firing of the Sprite ATO unit took place at Hatfield in 1947. It was intended to be an 11 s static test, done late at night. All went well so, with everything cleared up, the team departed. En route they met the film processor to hear the sorry news that the film had jammed in the cameras and the results were completely lost.

The "special cat" held by Roger Grimston (with John Nicholson) after the first flight of the Spectre on 18 December 1956. The cat became a member of the de Havilland Rocket Division as a light-hearted gift from the late Val Cleaver (BIS Chairman, 1948-50); it was the mascot of the first dozen flights. *Bottom:* Roger also produced this December 1949 photograph of the Sprite RATO motor with, from left: Wil: Neat, Val Cleaver, Roger Grimston and Ernest Dove.

Roger also recalled the first flight-test of the Spectre. As this was probably the first time that an aircraft in the UK was to be rocket-powered, a "special category licence," probably the first ever issued, was needed. To underline the "special cat" point they took aloft their very own cat mascot. Unfortunately, the "frivolous photo" taken on their return failed to generate amusement in high quarters. On the subject of high quarters, Roger described the first high-altitude flight, using these units. The aircraft, a Canberra, was normally able to reach 45,000 ft but, with the rocket motors turned on, it shot up to 60,000 ft at an incline so steep that it seemed almost like being in a lift!

If Only

A well wisher interested in improving my education recently gave me a third edition of *Popular Astronomy* by Simon Newcomb, published in 1880. Having found little of interest in the text I was just about to jettison it when my eye caught an appendix listing the astronomical works consulted by the author.

With one eye to our Society's Library collection I was immediately alerted, but then completely shattered to read that "the famous book by Copernicus published in 1543 is rare but the 2nd (Basel, 1566) sells for $4." Hardly able to credit my eyes, I read on. The two books by Tycho Brahe, so it said, sold for $6 for both. Bayer's *Uranometria,* which contains the celebrated charts in which stars were named with Greek letters for the first time, came out at $2.50* and the great work on the Moon by Hevelius, "profusely illustrated," peaked at between 4 and 5 dollars, though his volume on Mercury barely reached $1.

Unfortunately, *Cometographia* (folio, 1668) the first great treatise on the subject of comets, is unpriced, as is a similar volume by Pingre, *Cometographie*, which appeared in 1780.

Volumes nowadays valued at thousands of pounds each were, just a hundred years ago, going for a song!

* (Three or more editions were published, the first in 1603, the second in 1648 and the third in 1661).

Much ado

Some correspondents, much concerned to see that I put in a good day's work, feel encumbent to suggest additional labours designed not only to fill the small hours for years on end but bring to an end all other Society work. At least half a dozen suggestions of this sort arrive every day so that, over the year, they would probably absorb the total output of a small army.

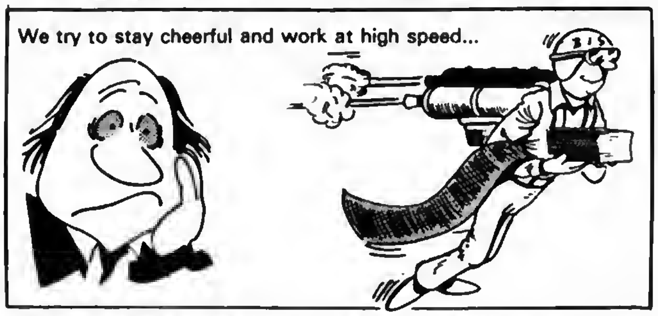
Little is omitted. Ideas emerge for firework displays, swimming galas, books to be written, produced and sold, large-scale raffles ("two first prizes of 10 million pounds each are suggested") setting up special groups to study e.g. the Korean airliner incident, space biology, CETI information; then there are personal requests "to help the Society" e.g. requiring assistance in writing books, arranging for special contacts or privileges to be extended by the UK, American or Soviet governments, collecting dolls signed by astronauts, arranging a holiday in Norway or finding a solicitor. Some go the whole hog e.g. "please

tell me how to set up my own SETI: I need details for building and operating a radar tracking system for sending signals into deep space and receiving answers." Interspersed are requests for help with poetry, sculpture, musical plays, acts or scenes, songs, and once writing a short opera.

Commercial operators loom large, though, fortunately, not so large as they once were. Free assistance in writing film scripts, undertaking extensive research and arranging special facilities and displays in the UK and abroad to enable the proposer to make an honest buck are invariably coupled with the ploy "it's publicity for the Society" though this is about as unlikely as anything could be. One operator didn't ask at all. He was the Editor of an erstwhile daily newspaper *The Recorder*. His paper simply announced that first prizes for a competition would be awarded by the Society and would consist of tickets for a Moon trip. They were forced to admit the blatent falsification. It was not so much a case of the dented mirror of the press as a magic mirror on the wall which saw things not apparent to the rest of us. The newspaper soon vanished from sight, no doubt under a burden of court cases. It was so quick that we lost the opportunity of seeking redress.

Much as one appreciates the thought which goes into all these suggestions one has to mention that the Society's daily round already fills most waking hours.

Probably my most difficult duty, over and above tasks initiated by the Council and its committees, is to act as a Human Memory Pad, to meet the requirements of a multitude of telephone calls and visitors and thousands of letters - most detailing actions, dates and times up to nine months hence. It adds up to tens of thousands of items to be remembered, acted upon and synchronized exactly every year. It is not good enough to get *nearly* everthing right. Failure just once brings instant retribution.



Well-wishers interested in nervous breakdowns might like to ponder on some of this and reflect upon the tasks we already carry out and are continually seeking to improve.

Postbags bulging with plans for work by other people can be counter-productive, even if "The Society" is designated as the body undertaking all these tasks - to give a false sense of security to those being lined up as the real targets.

Comet Runaround

Acquisition by our Library of a short treatise entitled the "Great Comet of 1882" reopened old wounds. Throughout the 17th, 18th and 19th centuries the skies were ablaze with spectacular cometary visitors, some e.g. Cheseaux Comet of 1744, with six or seven tails. Astronomical treatises of the time abound with beautiful drawings to record these events.

Not so the 20th century. It began well enough with the Great Daylight Comet of 1901 but that was completely invisible from the UK. There was little more to add to record Halley's comet in 1910. For most of us now alive, the skies have been devoid of anything other than an occasional small nebulous patch, introduced more as a test for the keen-sighted than anything else.

Peltier's Comet, in 1936, was a misty object in the sky in the constellation of Cassiopeia; Kohoutek was a complete let-down, from the UK at any rate. The situation was, fortunately, retrieved by the IRAS Comet which plunged towards the Earth headlong and became the nearest cometary visitor for several centuries. Its approach and departure coincided, unfortunately, with inclement weather in the UK but for those who knew *exactly* where to look a small misty patch in the sky, almost overhead, was their reward.

Mention of Kohoutek reminds me that a Society-sponsored trip from Gatwick to see it from above the clouds was organised. As the minutes to take-off ticked away I was to be found sitting in my car in Croydon in one of the biggest traffic jams ever!

Recent reports indicate that Halley's comet will be brighter than previously anticipated, in which event we may well have something to look forward to, at last. Those not willing to chance it can hedge their bets by joining the Society's excursion to witness the return of this most distinguished visitor in 1986. If the last 70 years are anything to go by, it may well be the only chance they'll get!

Smartypants

Members will soon be seeing our smart new envelopes, impressed with the Society's logo and address, to join our smart new letter paper, smart new membership certificates and even a smart new Society seal. Things are looking up all round.

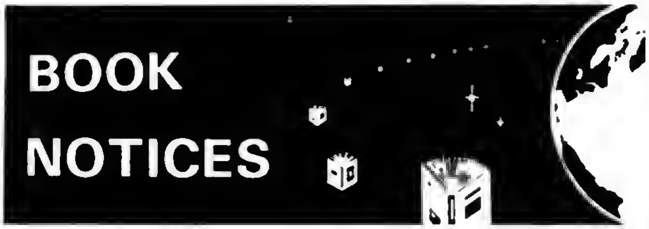
Spaceflight has already adopted a much improved format; the overwhelming view is one of praise. Even a member who grumbled at first took the trouble, afterwards, to tell us that he had changed his views so the score was almost a 100%. Even if one bears in mind the mandatory stricture that not everyone can be pleased all the time, we seem to have pleased practically everyone *this* time.

Exhibition Problems

I regard proposals for exhibitions with more feeling than most. About 20 years ago, with the idea of promoting the Society I undertook to mount an exhibition and demonstrations at the Biggin Hill air display. Most went according to plan. Sets of postcards had been prepared for free distribution, along with other giveaway material. The demonstration booth, manned by the late Professor Belyavin and Dr. Steavenson, showed the effects of cyrogenic liquids on things like bananas and tomatoes (with great success I might add). Left to me was the main task of setting up a large display of sounding rockets, rocket engines and similar artefacts. A preliminary enquiry about this had brought the assurance that "dozens of newly-recruited RAF lads" would be available to do the heavy work. It sounded fine.

Everything went well. The heavy exhibits arrived just before lunch in good time to enable the display to be completed by the deadline of 4 pm. Unfortunately, their arrival was a signal for the RAF helpers to fade away. They did this in good measure, leaving me in solitary state. They had gone for good. There was nothing for it other than to manhandle every exhibit into place single-handed.

This I did at the cost of a slipped disc and months of pain afterwards. Most may regard Biggin Hill affectionately, as a home of "the few." My feelings are even more tender.



Worlds Beyond: The Art of Chesley Bonestell
F.C. Durant and R. Miller, Donning Co. Publishers, 5659 Virginia Beach 8lvd., Norfolk, VA 23502, USA, 133pp, 1983, $14.95 (H/C $17.95).

Members posessing the set of 8onestell slides will be well aware of the contributions made to space art by Chesley 8onestell. His pioneering work has now firmly established space painting as a serious art form – and a very collectable one.

This volume is not just a collection of 8onestell's best paintings, but a tour through his life *via* his complementary interests: space, films and architecture. It may come as something of a surprise to *Spaceflight* readers to learn of the extent of his involvement in the latter.

Fred Durant's 15pp introduction present a thumbnail sketch of the man and tells us how Bonestell the space artist found some of his first inspiration, "I... hiked... 26 miles to... Lick Observatory. That night I saw for the first time the Moon through the 36–inch refractor, but most impressive and beautiful was Saturn through the 12–inch refractor. As soon as I got home I painted a picture of Saturn..." 8onestell was then 17 years old. Ever since, he has delighted the world with his vivid imagination and his creative skill.

The book – by one long-standing Society Fellow about another – is a delight.

International Halley Watch Amateur Observers' Manual for Scientific Comet for Studies
S.J. Edberg, Sky Publishing Corporation, 49 8ay State Rd, Cambridge, Mass. 02238-1290, U.S.A., 192pp, 1983, $9.95.

The arrival of Halley's comet in 1985–6 will probably be the most publicised astronomical event of the century. The present volume is an official NASA-JPL guide to show amateur observers how they might contribute to the scientific studies of this exciting event.

The volume is devided in two parts i.e. "Methods" and "Ephemeris and Star Charts." It contains enrolment and reporting forms for the International Halley Watch programme, information about the comet itself and an ephemeris on 19 detailed star charts of its position at daily intervals, with detailed descriptions of how useful observations may be made.

The International Halley Watch, already reported in *JBIS*, January 1984 (pp.28-31), is the organisation responsible for administering a world-wide scientific effort to study the close approach of the comet. Careful observations by users of small telescopes are needed to supplement the planned professional and spacecraft studies.

Those who miss the 1986 return must be prepared for a long wait. The comet isn't due back again until the year 2061.

The Cambridge Deep-Sky Album
J. Newton & P. Teece, Cambridge Univ. Press, 126pp, 1983, £9.95

This book, written both for the general reader and the amateur astronomer, is something different. The aim is to present the splendour and mystery of the Universe, not as seen through the world's greatest telescopes, but as might be viewed through a moderately-sized amateur instrument. It provides 126 celestial portraits of galaxies, nebulae and star clusters, all to a uniform scale i.e. all the telescopic fields are approximately the same size so that the relative sizes of the various objects can be judged. Each picture is accompanied by a wealth of data with text, data and photographs beautifully presented, object by object, to help readers wishing to search out these intriguing deep-space features for themselves. Instruments can range from a good pair of binoculars to (for some of the fainter objects) the largest backyard telescope.

Those interested in celestial photography, or willing to try it for the first time, will find the section on telescope cameras particularly valuable. The authors describe, in considerable detail, the design and construction of an amateur photographer's cold camera, methods of telescopic guidance, image enhancement, etc.

Planetary & Lunar Coordinates for the Years 1984-2000
HMSO, 321pp, 1983, £10.

The primary aim of this publication is to provide low-precision data for planning purposes in advance of the annual publication of "The Astronomical Almanac," in the expectation that it will be useful for many different applications e.g. the computation of orbits of comets and minor planets. The book consists of three parts for, wedged between a short introduction and a relatively short set of Tables, lies the main bulk viz the coordinates for inferior and superior planets and of the Moon.This continues a previous volume which related only to the years 1980-84. It follows the same general arrangement as before except that the coordinates now all refer to the mean equinox and equator or ecliptic, of the new standard epoch of J2000. Moreover, these coordinates are based on a new set of planetary and lunar ephemerides prepared by numerical integration at JPL in cooperation with the US Naval Observatory.

Eclipses for 1984 are sparse. There is only one total eclipse of the Sun, in November, which fits in well with the rule that these can only be seen from the most inaccessable places. Down under, those in Australia and New Zealand will probably have a good view, but otherwise the choice seems to lie between Antarctica or the extreme south of South America. These last two places feature, again, as the best spots for seeing the total solar eclipse of November 12th 1985. Stay-at-homes in the UK will have to wait until August 11th 1999. They will then have to journey only as far as Cornwall.

Astronomical Phenomena for the year 1985
HMSO, 73pp, 1983, £3.

This is a handy digest for those who don't want the "hard stuff" in the previous review. It presents astronomical data in UT (also known as GMT) and lists the Moon's phases, planetary phenomena, visibility of planets — including some minor planets, sunrise and sunset and moonrise and moonset. It also present such incidental information as the facts that the Byzantine year 7494 begins on September 14th and the Nabonassar year 2734 on April 27th. Those who fondly believed that the Earth reached perihelion on Jan 1st will be interested to know that the exact date is Jan 3rd, and that aphelion will not be on July 1st but July 5th 1985.

Surveys of the Southern Galaxy
Ed. W.B. 8urton & F.P. Israel, D. Reidel Publishing Co., 309pp, 1983, $46.

Even though the present era of galactic research began some 60 years ago, problems associated with the general scarcity of observations of the southern sky still persist. During the past few years, however, considerable progress has been made in securing fundamental data of the southern sky and interpretations, based on combined southern/northern surveys, are beginning to produce balanced descriptions of galactic morphology.

The present volume, the Proceedings of a meeting in 1982, consists of papers presenting results of various surveys. Some are particularly concerned with gamma-rays surveys, others examine large-scale galactic structure. Included are a number of detailed surveys, some concerned with the galactic centre and which report, from a large-scale survey of OH, that molecular clouds are distributed in a bar-like structure at least

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Most of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

2 kpc in diameter with the outer parts of the bar warped out of the galactic plane. Others are concerned with external galaxies. The Proceedings conclude with descriptions of some of the survey instruments used, in which spaceborne equipment looms large, for the latter have done more than anything else to reduce the disparity between observations of the southern and northern hemispheres.

Several maps based on combined northern and southern data from standard reference surveys are included as appendices. Among these are comparable maps of the HI and CO distribution in the first and fourth galactic quadrants, sky maps of gamma-ray emission over selected energy ranges, HI integrated emission over selected velocity ranges, and radio continuum flux at 408 MHz. Also included is a map of the HI surface density in M31, made with linear resolution comparable to that of standard single-dish surveys of our own Galaxy.

Understanding the Universe: The Impact of Space Astronomy
Ed. R.M. West, D. Reidel, 249pp, 1983, $34.50.

This volume contains some of the papers presented at Unispace 82, prepared at a level which can be easily understood by the interested layman and centering on some of the most fundamental current problems in modern astronomy. There are five contributions, one on the atmosphere of the Sun and stars, another on the solar-terrestrial relationship, a third on the size, shape and temperature of the stars, and the fourth on X-ray and gamma-ray astronomy. The volume ends with a look at the impact of space developments on cosmology.

The result is a well-produced volume, easy to read, clearly presented and even though the first paper is printed in French (the others are all in English) it contains a short summary that tells the English reader what it is all about.

Space Manufacturing
J.D. Burke and A.S. Whitt (eds), American Astronautical Society, 1983, pp.496, $60 (hard cover), $50 (soft cover).

Volume 53 of the "Advances in the Astronautical Sciences" series presents papers from a conference held over 9–12 May 1983 at Princeton University. Sections include: "Space Stations and Habitats," "Manufacturing," "International/Legal Considerations," "Materials Resources and Processing," "Accelerators and Asteroids" and "Economics."

The "Interstellar Nomads" paper by E.M. Jones is particularly interesting and probably the most forward-looking in the volume, considering the establishment of permanent colonies on comets! Other papers discuss the extraction and refinement of lunar and asteroid ores, together with the requirements for space-based manufacturing systems. The economics of commercial space ventures are also considered.

A total of 54 papers were included in the symposium.

Developing the Space Frontier
A. Naumann and G. Alexander (eds), American Astronautical Society, 1983, pp.436, $55 (hard cover), $45 (soft cover).

This book, Volume 52 in the "Advances in the Astronautical Sciences" series, consists of the proceedings of the 29th. AAS Annual Conference held on 25–27 October 1982 in Texas on the theme of "Developing the Space Frontier."

Some 45 papers were presented under the headings of "US Space Policy: Its Formulation and Implications," "Government and Private Roles," "Status, Plans, Implementations and Requirements: Government and Private Sector," "Preparing the Base for Space Development," and "STS Status and Projections."

The latter section includes a paper by astronaut Dick Truly on flying the Space Shuttle, and the work underway at Vandenberg Air Force Base to prepare it for Shuttle polar operations.

Future space exploitation, though, was the key to the conference. Papers on Space Station Utilization, commercial activities — both in processing and launch vehicles — are discussed in detail. The space community in general clearly believes that commercial operations are vital to the full development of space resources.

Supernova Remnants & Their X-Ray Emission
Eds J. Danziger & P. Gorenstein, D. Reidel Publishing Co, 1983, 614pp, $72.

The main thrust of the Symposium papers presented here was to introduce discussion of the X-ray images and high-resolution spectra from a variety of supernova remnants obtained from the Einstein Observatory though some additional optical, radio and theoretical results are also included.

Major topics discussed included young supernova remnants-their structure, mass and interaction with the interstellar medium; middle-aged supernova remnants, with emphasis on objects with centre-field morphologies as seen in radio and X-rays; the older supernova remnants and their effect upon the interstellar medium; plus compact objects associated with supernova remnants and objects of this sort which appear in other galaxies, particularly X-ray optical and radio results relating to SNRs in the Magellanic Clouds.

Among the new results presented is observational evidence for the presence of a reverse shock in enhanced elemental abudancies and non-equilibrium ionization in the young SNRs. Activity from a neutron star also plays an important role, or is otherwise present, in a number of remnants.

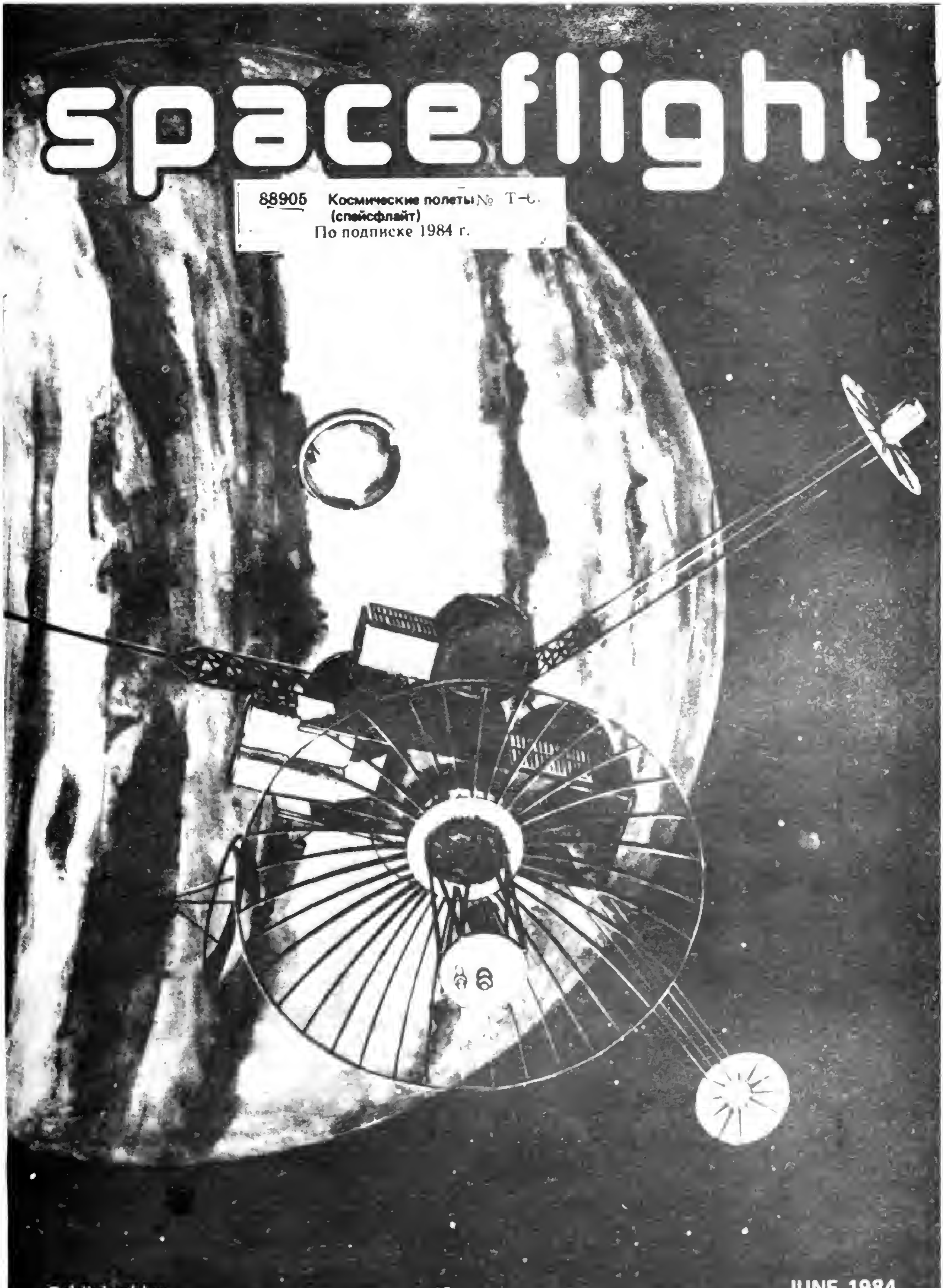
An appendix lists all presently-known SNRs in our galaxy. Of the 135 listed, only 40 have been seen optically and 33 observed in X-rays.

Accretion-driven Stellar X-ray Sources
Ed. W.H.G. Lewis & E.P.J. van den Heuvel, Cambridge Univ. Press, 450pp, 1983, £40.

Many recent developments in astronomy have stemmed from the advances in space technology which made it possible to observe spectral regions to which the Earth's atmosphere forms an opaque screen. So far, of all the various branches of the new space astronomy, the one that has produced the most abundant crop of unexpected results is X-ray astronomy. The X-ray sky was found to be much more active than anyone had anticipated. Surprisingly, strong galactic and extra-galactic X-ray sources appeared. Advances into this new spectral band led to the discovery of new celestial phenomena. For example, it was found that most bright galactic X-ray sources are powered by an accretion of matter upon collapsed objects, frequently neutron stars. The gravitational potential energy set free by matter reaching the vicinity of a neutron star is enormous and, most importantly, this energy is released in a very small volume. The result is that the matter contained in this volume is heated to such an exceedingly high temperature that its thermal radiation falls into the spectral range of X-rays. This is in stark contrast to typical ordinary stars where large amounts of energy are released by nuclear reaction but spread over very large volumes and, consequently, generate lower temperatures — with the result that the star radiates in the optical rather than in the X-ray spectral band.

This book is right to the fore in one of the most exciting and rapidly evolving areas of modern astronomy and astrophysics. It presents a review of present understanding of X-ray emitting stars i.e. those fuelled by accretion. The topics discussed include X-ray pulsars in massive binary star systems; X-ray burst sources; the emission of X-rays from normal galaxies; accretion to dwarfs in close binary systems; optical observations, etc.

spaceflight



Published by

JUNE 1984

SPACE '84

16-18 November 1984

SPACE — THE FUTURE OF MANKIND

Our programme for Space '84 at the Brighton Centre introduces a wide variety of space experts covering a wide range of space subjects.

The meeting will be divided into sessions on: New Frontiers, Discovering the Universe, Foothold in Space, Energy and Resources, Advancing Frontiers, the Future of Mankind and Workshop.

The preliminary programme is as follows:

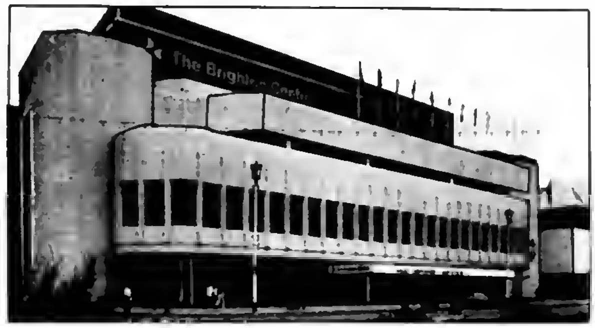
Dr. G. E. Mueller	:	Space: The Future of Mankind
Dr. W. I. McLaughlin	:	The Philosophy of Extraterrestrial Intelligence
Prof. M. Rees	:	Space Astronomy
Dr. J. K. Davies	:	New Eyes in Space
D. L. Pivirotto	:	Space Platforms and Autonomy
I. Bekey	:	Space Tethers
L. Blonstein	:	Steps to Space
Dr. D. G. Shapland	:	Spacelab
Dr. J. T. Houghton	:	Remote Sensing of the Oceans
C. Honvault	:	Operational Meteosat
J. Casani	:	Project Galileo
R. P. Laeser	:	Voyager: Now to Neptune
Dr. A. R. Martin	:	Space Resources and the Limits to Growth
R. M. Jenkins and D. C. R. Link	:	Giotto Update
Dr. G. Haskell	:	Asteroid Probe
S/L R. M. Harding	:	Space: Human Physical and Mental Adaptability
Dr. R. C. Parkinson	:	Space Colonisation
A. T. Lawton and P. Wright	:	Monopoly: Advanced Propulsion for the Future
R. Gibson	:	European Involvement in Space Station Development
R. J. H. Barnes	:	to be announced
G. Whitcomb	:	Missions for ESA's Science Programme

Remember: this is only a preliminary programme and changes will inevitably occur. Further details will be published in *Spaceflight* and *JBIS* as they come to hand.

Civic Reception and Banquet

A Civic Reception (dance/supper) by courtesy of the Brighton Corporation will be held in the Brighton Centre on the Friday evening to give everyone an opportunity to meet before the conference proper begins.

Highlighting Saturday's social activities will be a Banquet with Guest Speakers Sir Peter Masefield and Patrick Moore. The aperitif, 4-course meal and half bottle of wine per person will be provided at a cost of £18.00 per ticket.



To keep the friendly atmosphere of Space '82, the number of places available will be held down to 400. Experience shows that these will soon be snapped up, so early application is essential. Simply fill out the form below and send it to The Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

SOUVENIRS OF THE OCCASION

Space '84 souvenirs will take the form of commemorative mugs and decanters all embossed with the Society's motif and the Space '84 logo added for those who would like this too.

Several types are available: pint sized tankards at £10, and half-pint tankards at £3. Special silver-handled half-pint tankards in presentation boxes are available at £7.50. Decanters at £25 are also available.

Post orders will be accepted from members unable to attend our conference personally. These orders (UK only – sorry but we can't run the risk of damage in sending abroad) should be sent direct to:

The British Interplanetary Society,
27/29 South Lambeth Road,
London, SW8 1SZ.

Yes, please send me a registration form and other details on Space '84. I enclose a 20p stamp.

Name: ....

Address: ....

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spaceflight

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CONTENTS

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TWENTY-FIRST CENTURY SPACE

One of the most serious problems facing our species today is the uncomfortable rate at which its numbers are expanding and the impoverished circumstances in which the majority of its members are forced to eke out an existence. By the end of this century the world population, on the basis of present trends, will have reached about 6000 million and the most conservative demographic assessments suggest that the number of human inhabitants of this planet will have attained a level of 10,000 million by the middle of the Twenty-First Century. The viability of human civilisation will depend on our descendants being able to maintain this huge population in living conditions which are significantly better for its poorest members than those which obtain today. It is inconceivable that this can be achieved other than by the fullest exploitation of science and technology in both industry and agriculture. But,for all Man's technology, the achievement will not be possible without adequate material resources to meet demands several-fold greater than those of today. This must give considerable cause for concern, bearing in mind that resources of many vital substances in the continental crust are already extended to the limit at the present rate of extraction. Where is Man to look for the even greater quantities of these crucial materials that will be needed in this not-so-distant future? If they are needed in bulk and it is not possible to find substitutes, then he may seek and find them below the surface of the oceans but it seems inevitable, ultimately, that Man will have to go beyond the confines of the Earth to expand his vital raw-material resources.

In the gravitational shallows of the asteroids and of minor moons of our Solar System there are vast areas of exposed surface rich in minerals relevant to Man's economy. It may demand a considerable extrapolation of our technology in robotics and remote handling before we can extract and process these riches in inhospitable environments, so far removed from the Earth, but such developments should be well within the reach of Twenty-First Century engineering. The task of transporting great quantities of processed ores from the mining sites to Earth-orbital stations and of transferring the products of their refinements from thence to the surface of our world will call for considerable development in space propulsion and re-entry techniques but all of these can be envisaged in terms of known technology.

This space commerce would not end with the extraction and transport to Earth of raw materials. Nearer to home the space environment lends itself to the development of techniques for processing materials and for manufacturing artifacts that cannot be matched on the surface of this planet. Much has been made, recently, of the potentialities of processes carried out under free-fall conditions which would yield products superior to their Earthbound counterparts, or even some impossible to form in the surface gravitational field. We do not need to look as far as these novel possibilities to recognise that, in space, we have the perfect environment for more mundane applications of vaccum technology that already plays a considerable part in modern industrial processes.

[Continued on p. 288

The Galileo spacecraft approaches Jupiter in 1988. This artist's impression shows the atmospheric probe shortly after separation from the orbiter portion. A Galileo update will be included in next month's "Space at JPL."
NASA/JPL

AGORA: ASTEROID RENDEZVOUS

By Dr. A. Balogh

As reported in February's *Spaceflight*, the European Space Agency is studying the possibility of flying a probe to the asteroids in the 1990's. Agora (Asteroid Gravity, Optical and Radar Analysis) would survey several targets using an array of instruments. The author, one of the study team, describes Agora and how it fits into our search for knowledge of these small bodies.

Introduction

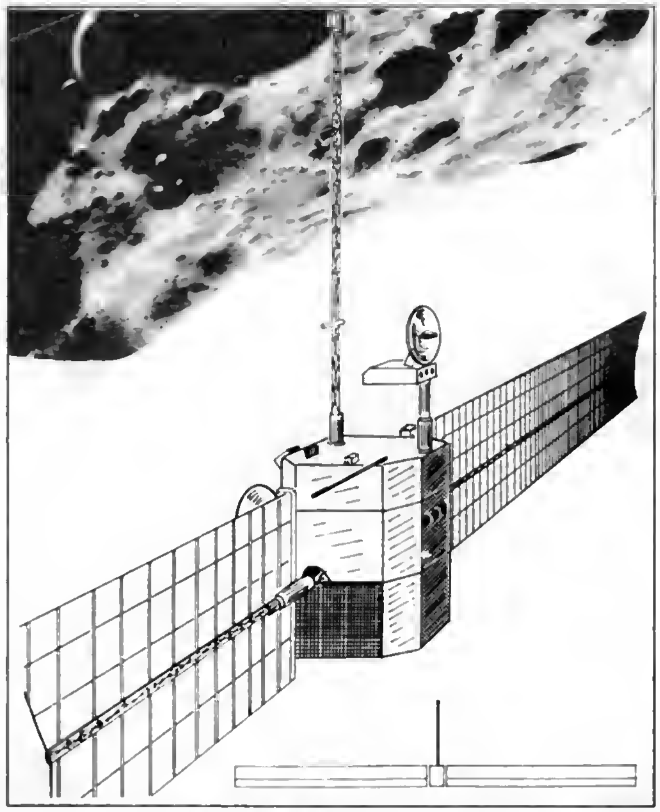
Missions to the asteroids have been studied over the past few years both in the US and Europe. They have ranged from relatively simple fast ballistic fly-bys of a few asteroids to more complex missions, including sample return and even the exploitation of the suspected mineral wealth of asteroids. While these more exotic missions may well be undertaken in the next century, in the foreseeable financial climate such missions do not figure in the plans of NASA or ESA.

The European approach has been to establish the feasibility of a scientifically valuable first mission. Exploratory trips are necessary, anyway, before drawing up plans for more ambitious excursions. The discipline, both technical and financial, imposed on projects studied within ESA has resulted in practical plans for a first exploration of the asteroid belt. After carrying out two studies of ballistic fly-bys (Asterex 1 and 2) in 1979 and 1981, ESA undertook the assessment for asteroid rendezvous: Agora.

Justification

By the early 1990's, asteroids will be the only major class of objects in the Solar System still awaiting the visit of a space probe. Although asteroids are not spectacular, as even the largest of them are only star-like, unresolved objects in the largest of ground-based telescopes, their scientific interest is considerable. This interest, which has been increasing in the past decade, stems from the fact that they are thought to be closely related to the very early stages of the Solar System. No-

Earth-based photographs of asteroids reveal only star-like images. This is the discovery photograph of 1982TA from the Palomar Observatory. *World Space Foundation*



The Agora craft (after A. Langenhoff, ESTEC, Noordwijk).

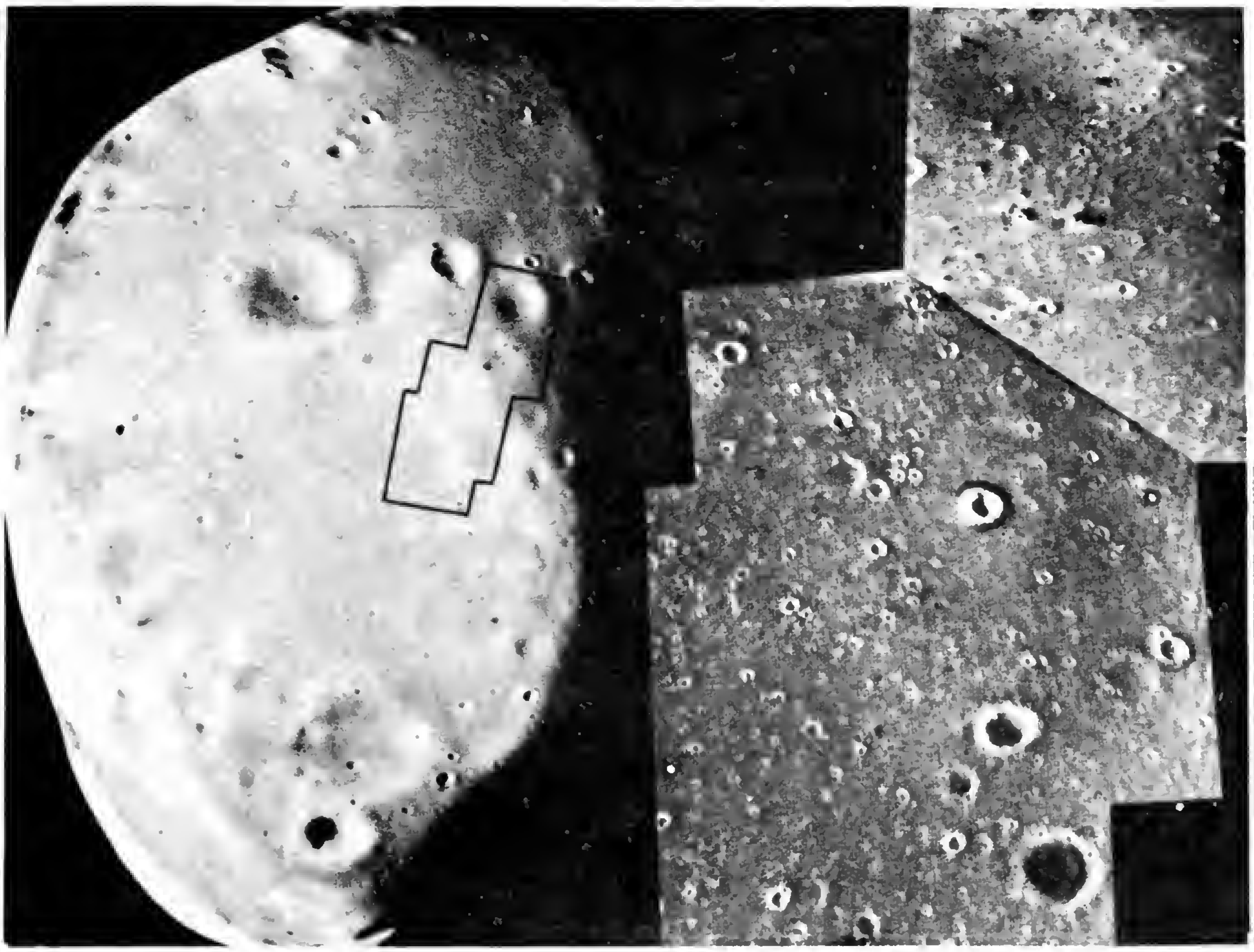
one nowadays seriously believes they are the remains of an "exploded planet." Asteroids are widely accepted to be the descendents of a group of planetesimals (small objects in the inner part of the early Solar System) which could not complete the process of planetary formation because of nearby Jupiter. It seems likely that giant Jupiter, directly or indirectly, marshalled these small objects by repeatedly disturbing their orbits to form a population of "minor planets" which, through numerous collisions with each other and the effects of Jupiter's gravitational field, have been shaped into the asteroid belt as we know it.

Asteroids are also of interest because of their likely relationship with meteorites. Although it seems probable that meteorites originate in the main belt, the underlying dynamical processes are little understood. If a firm relationship could be established, the vast quantities of meteoritic material collected on Earth could be examined again from a new perspective.

For more than 150 years after the dicovery of the first asteroid, Ceres, in 1801, asteroid research consisted of finding new objects. Over 2000 have now been catalogued. However, since about 1970, ground-based research has been intensified with the emphasis now on the physical characteristics. A classification, according to their spectral features, has been established; we also know the estimated diameters of several hundred objects, as well as their rotational periods and a number of other characteristics. From observation of the light curves we know that many are oddly shaped, and there is a strong likelihood that some have companions. While such studies are continuing, there is a need to calibrate the accumulated ground-based data with close-up observations of representative asteroids. It is the maturity and success of ground-based studies that provide the strongest arguments for a visit to the asteroid belt.

Agora: Rendezvous with Vesta

The first difficulty is selecting a target. It is impossible



Some idea of the general appearance of asteroids may be gained from the Viking images of Phobos and Deimos, the small moons of Mars. Viking 2 produced this view of Deimos in October 1977 from a distance of 500 km. The close-up area shows a resolution of 2 m. *NASA*

to visit more than half a dozen out of more than 2000 potential bodies. The prime requirement placed on Agora was to encounter two or more asteroids, one for rendezvous. The latter implies the craft has to be put into a temporary orbit around the asteroid. The prime target chosen was Vesta, the nearest and most easily accessible of the large main belt asteroids. Vesta has a sizeable diameter (550 km), but is of unknown (or unclassified) spectral type. It has been suggested that it might be one of the differentiated asteroids: it seems probable that early in its history its core melted and then resolidified to give a core-mantle type structure. We know very little about such processes in the early Solar System, and any confirmation that they have occurred in asteroid-size bodies would be of great significance.

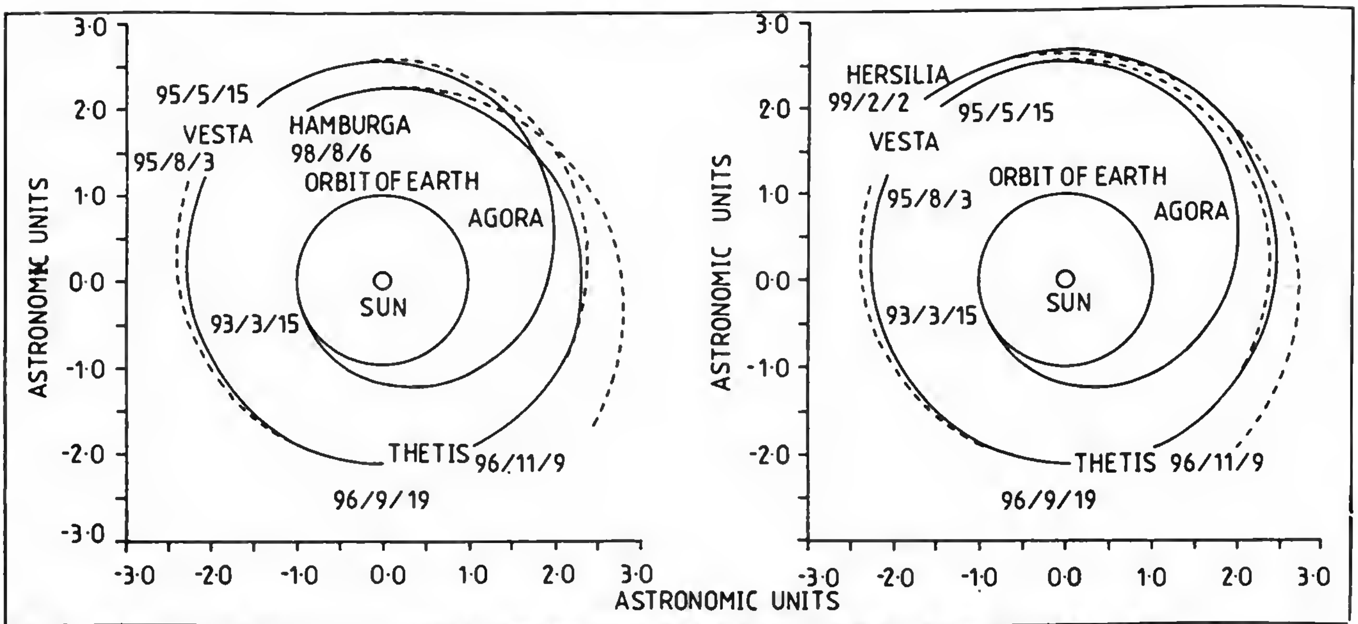
Once rendezvous has been achieved, the probe moves in an asteroid-like orbit and further rendezvous or low speed fly-bys can be envisaged. The large number of bodies in the main belt ensures that subsequent targets can be found relatively easily.

Several specific missions were considered in detail during the Agora study. The orbits involved in two are shown in the diagrams over page. The main criterion was to rendezvous with Vesta and encounter (rendezvous or fly-by) at least two more asteroids. Preferably, the additional targets had to be of different sizes and spectral types.

It is very difficult to launch a probe ballistically from Earth (i.e. with thrust applied at launch and followed by an unpowered cruise) into an asteroid-like orbit. While reaching the asteroid belt on a highly eccentric elliptical orbit is possible using the European Ariane launcher, such orbits are suitable (with onboard chemical propulsion for targeting and terminal navigation) only for fast fly-by missions. Such missions had already been studied by ESA and, although scientifically valuable, they limit the amount of data returned.

In order to achieve a less eccentric orbit with a semi-major axis of about 2.5 Astronomic Units (i.e. 2.5 times the average Earth-Sun distance), in-orbit propulsion is required to change the velocity of the probe by 10–15 km/s. Ion propulsion is the ideal means. Its principle of operation is relatively simple: mercury ions are accelerated to about 30 km/s and ejected to provide thrust. The chief advantage over 'ordinary' rockets is the very good thrust-to-propellant ratio. Its chief disadvantage is the low thrust level; this can be overcome by thrusting for long periods along the orbit to generate the required change in the velocity of the probe. A further disadvantage is the large electrical power level to drive the engine.

Ion propulsion systems have been studied for a number of years but they still await full scale development and qualification for space use. A relatively small engine (RIT-10) has been developed in Germany and used for design proving. A scaled-up version (RIT-35) has also been built as a laboratory prototype. Its thrust level is adequate (about 140 mN) and the Agora study has been based on the use of six such engines. Further development work has now been undertaken on behalf of ESA as there is a range of potential applications in deep-space and planetary missions.



Ecliptic projections of the orbits of two missions considered during the Agora study (after M. Hechler, ESOC, Darmstadt).

The Spacecraft

The spacecraft is designed to satisfy three main requirements. First, it has to be directed after a long partly-powered cruise phase to the targets. Second, once inserted into the rendezvous orbit around an asteroid, the scientific instruments must be able to perform the required observations. Third, the data must be transmitted to Earth.

Agora's main feature is the very large solar array to provide the required electrical power. Since the solar energy available is inversely proportional to the square of the distance to the Sun, the power available at 2.5 AU is only about 15–20% of that at Earth. (However, as the temperature of the array falls as the spacecraft moves away from the Sun, its efficiency increases). The main consumer of power is the ion propulsion system, needing a little over 4000 W to operate at full thrust. The payload and other subsystems need a modest 300 W. Although alternative power sources were considered, none appeared to provide a better solution to what is clearly one of the most difficult design aspects.

Each of the two array wings is 30 m long and 3.3 m wide, providing an area of 200 m^2. The array is designed to generate nearly 25 kW of electrical power at the beginning of the mission at 1 AU (i.e. at Earth orbit). This size of array is close to, but within, the limits of current technological feasibility.

A vital aspect throughout the mission is the determination and control of the spacecraft attitude. The solar panels must be at 90° to the solar direction, in order to maximise power; the ion thrusters must be aligned along the direction of optimal thrust; the antenna dish must point to the Earth for maintaining the communication link; finally, the payload must be pointed at the target with high accuracy and stability. Attitude is determined with a set of Sun and star sensors. Control must be largely autonomous since the return trip of radio signals *via* Earth would take up to 50 minutes. Onboard autonomy is achieved with pre-programmed control sequences stored in the computer memory and activitated from the ground for the various mission phases. Once a sequence begins, the craft can control its own attitude using its sensors, thrusters and reaction wheels. To make the payload independent, it is mounted on a platform able to move freely in two directions.

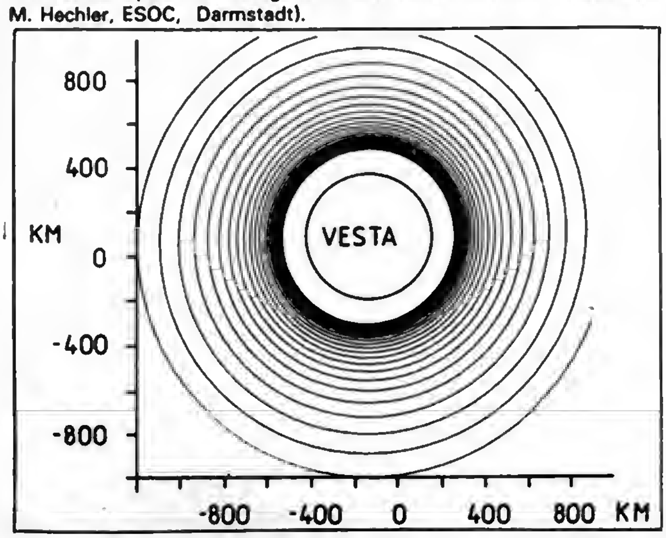
The communications link uses a relatively modest maximum of 2 kbits/s. (Europe does not have an equivalent to NASA's Deep Space Network). Transmitting images of the asteroid, however, require several megabits/image. Some data compression can be performed onboard but a very large (260 Mbits) bubble memory has been included to act as a buffer between the payload and the ground link.

Scientific Objectives and Payload

What are the objectives of Agora? In the first place, what we lack most are resolved pictures of asteroids. Detailed photography, in different wavelength regions, is naturally a prime objective. Just how much can be discovered by simply imaging a body with sufficiently high resolution has been amply demonstrated by Voyager. The photographs of the moons of Jupiter and Saturn have led to significant advances in understanding these bodies in particular, but also more generally in planetology. Surface structure and morphology, indications of mineralogical composition and the collisional history of the target asteroid are the basic data expected from a first asteroid mission.

A basic clue to the overall composition of the asteroid is provided by its density. The simple equation, mass/volume = density, can be solved only if the two items

The descent spiral orbit of Agora for the rendezvous with Vesta (after M. Hechler, ESOC, Darmstadt).



on the left side are known with sufficient precision. During the rendezvous phase, the mass of the asteroid can be found from tracking data since the orbit will be partly affected by it. A fast fly-by, on the other hand, does not produce a large enough deviation in the probe's path. In order to measure the mass during a fly-by, a test mass will be ejected and its path tracked by the camera and radar. The asteroid volume can be found from measuring the images (including stereoscopic pairs).

It is better to explore as wide a spectral band as possible, in particular towards the longer wavelengths. Imaging in the infrared can help to detect many mineral assemblages, such as the different classes of silicates and hydrated minerals, as well as iron-nickel materials. Microwave radiometry can determine the temperature variations on the surface and the thermal properties of the upper layers.

An important objective is finding the elemental abundances in the uppermost crust by measuring the spectrum of radioactivity-generated gamma rays. Such a measurement cannot be performed on short-duration fly-bys.

It is impossible to predict whether asteroids are magnetised. Any positive indication of fossil magnetisation would be of great importance, making it a worthwhile measurement.

During the long history of the asteroid belt numerous collisions have taken place. One likely product is dust; we expect to find a higher concentration in the belt itself and suspect that it is one of the major sources of dust found elsewhere in the Solar System. This needs experimental verification.

Defining the payload was a substantial part of the Agora study. It was considered essential that payload capabilities and requirements should match the stated scientific objectives closely. Not surprisingly, it was found that the use of multi-purpose planetary platforms or the re-use of other spacecraft fell well short of realistic requirements. An asteroid mission is unique both in its objectives and the means to achieve them. Commonality with other spacecraft and payload elements exists on subsystem level, but the "packaged" whole is unique.

The prime payload complement of Agora includes two cameras. The Wide Angle Camera has a 8° x 8° field of view and a ground resolution of 75 m from 500 km. Its main objective is to survey the surface of the asteroid during the encounters. The High Resolution Camera has a field of 0.57° x 0.57° view and it can resolve 5 m from a height of 500 km. It also plays an important role during the navigation phase by providing pictures of the asteroid against the star background to help with the approach.

An infrared imaging spectrometer will provide imaging capability at longer wavelengths. The radar altimeter, used to determine accurately the distance to the asteroid, can also be used, in its passive mode, as a microwave radiometer.

The gamma-ray spectrometer is used for the determination of chemical abundances close to the asteroid surface. Any remnant magnetic field will be detected by the magnetometer carried on a long boom well away from the background field of the spacecraft. Lastly, a dust detector will measure the particle field in the asteroid belt in general, as well as near the asteroid.

The long cruise phases between asteroid encounters will be put to good use to explore that region of interplanetary space. A small, but scientifically valid, interplanetary payload is included in the mission.

The Mission Sequence

Launch of a typical mission will take place from Kourou (French Guyana) using an Ariane 44L launch vehicle, in February/March 1993. The transfer orbit to Vesta, using the ion propulsion module, will last 792 days, including about 90 days for terminal navigation. The entry spiral to low altitude orbit will take a further 30 days. The main observation phase, in orbit around Vesta at 100 km altitude, will last about 10–20 days. The craft will then slowly spiral away from Vesta (about 40 days) and will be targeted to the next encounter.

A concept for a US asteroid mission based on the Tiros Earth-orbiting weather satellites series. Painting by Paul Hudson.

During the last month or so before insertion into the low altitude Vesta orbit, the cameras will provide a complete coverage of the asteroid surface with increasingly higher resolution. At this stage it will be possible to control the payload platform from Earth. During the phase of closest approach good coverage will also be provided by the infrared and gamma-ray spectrometers, the radar altimeter/microwave radiometer, the magnetometer and the dust detector.

Each rendezvous will yield literally thousands of images and a good deal of other data. The wealth of data will allow scientists to examine Vesta and the other targets in sufficient detail to test many of our theories. These results should also help in planning the more ambitious missions of the future.

Conclusion

The study has shown that a rendezvous mission to the asteroids is scientifically exciting and technologically feasible, although it does present a challenge to develop specific capabilities, such as ion propulsion, which may be applicable to other missions. Since the conclusion of the study, ESA has embarked on further development work in such critical areas as the propulsion module, the large solar array and the software required to optimise the mission trajectory. At the same time, discussions are taking place with NASA to explore potential collaboration in a mission based on Agora. Overall, the signs are good that such an asteroid mission is likely to fly before the end of the century.

MILESTONES

March 1984

7 NASA and Italy agree to joint development of a tethered satellite system for the Shuttle and the Lageos 2 geodetic satellite. Both will fly in 1987.

12 NASA are requesting bids for proposals to redesign or modify the Shuttle main engines in order to increase the operating lifetimes.

14 Shuttle Orbiter *Challenger* is mated to its boosters and external tank for Mission 41C, launch due 6 April. Lockheed Space Operations Co. now has responsibility for Shuttle processing, taking over from Rockwell. A record 55 day turnaround is the target before this launch. The combination is rolled out to the pad on the 19th. and a countdown test held with the crew onboard during 20th and 21st.

15 Novosti announces that the Soviet-Indian Soyuz crew (Malyshev, Strekalov and Rakesh Sharma) are in the final stages of preparing for their launch to Salyut 7. Indian radio announces it as the 3rd.

19 NASA's Advanced Communications Technology Satellite has been restored to the agency's budget by Congress. NASA dropped the project because, it was claimed, a 1988 Hughes satellite would duplicate much of the technology.

19 NASA has awarded a $390 million contract to Martin Marietta to produce a further 21 Shuttle External Tanks.

19 A five day demonstration of transatlantic video teleconferencing *via* satellite begins. The link between Washington DC and London uses a 2.4 m Comsat dish in the US and an Intelsat satellite above the Atlantic.

19 Marc Garneau has been selected by the National Research Council of Canada to fly on Shuttle mission 51A in October. The Canadian Anik communications satellite and 11 other investigations will be carried.

20 The Fairchild, Rockwell and RCA companies are awarded study contracts for the US Topex satellite. Topex will study the oceans for three years, beginning in 1989, to determine global ocean circulation.

25 A week-long series of observations of Comet Crommelin by the International Halley Watch begins as a trial run for Halley's appearance in 1985/6.

27 A three day symposium begins at NASA's Marshall Space Flight Center to present preliminary results from the Spacelab 1 mission.

27 Jesse Moore will become NASA's Acting Associate Administrator for Space Flight next month, it is announced, replacing Lt. Gen. James Abrahamson.

Please note that some of the dates quoted above refer to the "announcements" of the events and not necessarily to the events themselves.

DO YOU KNOW?

This 1974 photograph shows a special piece of space equipment with two of the men that tested it in orbit. Who are they and what is the unit? Answer below the picture.

Novosti

Answer: Cosmonauts Anatoly Filipchenko (left) and Nikolai Rukavishnikov were launched aboard Soyuz 16 on 2 December 1974 to test the new androgynous docking unit for use the following summer during the joint Apollo-Soyuz mission.

DO YOU REMEMBER?

25 Years Ago...
28 May 1959. Monkeys Able and Baker are recovered after a flight in a Jupiter missile nosecone. Although Able died soon after the flight Baker still lives as a visitor attraction at the Alabama Space and Rocket Center.

20 Years Ago...
28 May 1964. Saturn SA-6, a Saturn 1 development flight, is launched from Cape Canaveral carrying an Apollo boilerplate module.

15 Years Ago...
21 May 1969. Apollo-Saturn 506, Apollo 11, moves to the launch pad for the first manned lunar landing mission.
5 June 1969. NASA launches OGO 6 from California. This was the last in the series of geophysical observatories.

10 Years Ago...
29 May 1974. Soviets launch Luna 22 from Tyuratam. This lunar orbiting spacecraft carried out extensive manoeuvring above the Moon.

5 Years Ago...
7 June 1979. India's second satellite, Bhaskara, is launched by the Soviet Union from Kapustin Yar for Earth Resources studies.

K.T. WILSON

The Morality of Space Exploration

Sir, Moral questions arise over all major items of expenditure which do not seem to improve the human condition directly. Although it is widely recognised that Earth observation satellites have the potential to benefit everyone, the more esoteric space missions are often attacked on the grounds that there are more important human problems towards which the resources should be diverted. This is an argument that cannot be lightly dismissed. People who do not have enough to eat cannot be expected to show a great interest in the structure of the lunar regolith or the composition of the Venusian atmosphere. As individuals they stand to gain nothing from the data returned by distant space probes.

On the other hand, it is very likely that no other field of activity will prove to be more important in the long term. The use of extraterrestrial resources would ease the growing industrial pressure on the Earth's natural environment. Since we do not yet have an inventory of the Solar System's economic potential we would be failing in our duty to future generations if we did not begin to compile one. This is the most important argument in favour of funding space exploration in today's world.

In the words of the President of Sri Lanka, taken from his message to the Unispace conference held in Vienna in August 1982, "if it did not result in improving the quality of life, all knowledge would be barren and all science bereft of any meaning for billions of people on Earth." The only morally acceptable reason for investing in space, as with all other major science projects, is to strengthen the world economy to improve the human condition.

Since, from a moral point of view, the benefits from the exploitation of outer space must ultimately reach the whole human population it follows that this must be ensured by some kind of international mechanism. I would suggest that a global space agency, perhaps organised on the lines of ESA, is probably desirable.

Even now, with only a small fraction of the population benefiting significantly from industrialisation, the end of some economically important terrestrial materials can be foreseen. Space exploration is therefore a necessary and justifiable investment for the future of the world economy. It is not improbable that the survival time of *homo sapiens* will be increased by many orders of magnitude as a consequence. But we should not be unaware of the short term cost to a world that has many pressing problems. Above all, we must treat the moral questions with the gravity they deserve and not with the flippancy often accorded to them.

IAN CRAWFORD
Cheshire

BIS Spaceship

Sir, I was always fascinated by the ideas of space travel and my interest was increased by articles in the BIS Journals for 1937. There was much on Chemistry, Mathematics and Engineering but little on the provision of life-sustaining environment. Thinking of these problems whiled away many tedious war-time watches at sea. In 1949 I was asked by Dr. Shepherd of the BIS Technical Group to assist in making 1/50th scale models of various rockets then in existence; also a larger model of the Life Compartment of the BIS spaceship to illustrate the principle of a static view from a rotating ship using the Coelostat (to be provided, but it never was).

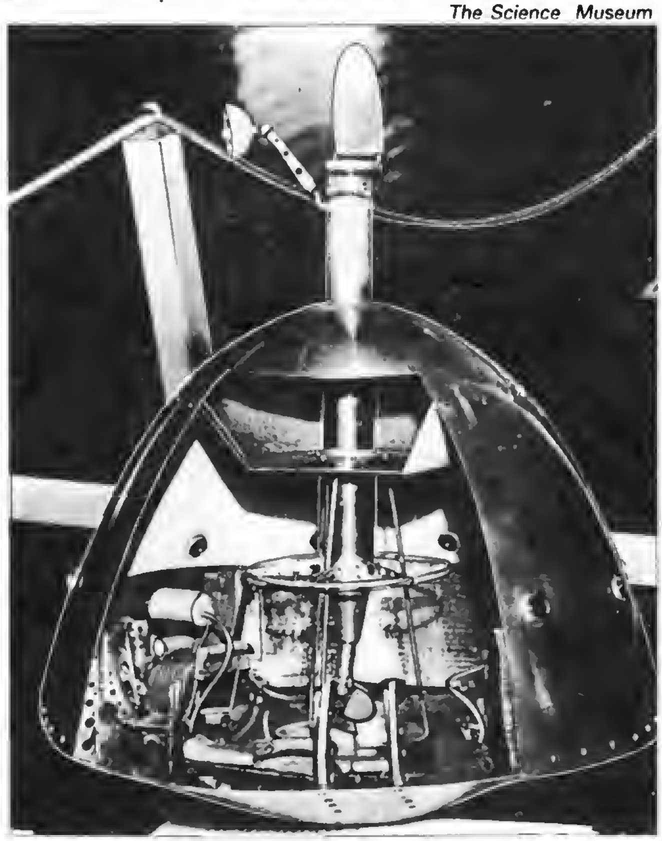
After making sketches and more detailed drawings the construction got underway, followed by many weeks of work in the garage or on the dining table. Being a lecturer at a Technical College I was able to use the laboratory facilities to test various materials and conduct experiments to discover the best structures and finishes most suitable to ensure heat equilibrium of the design and so on.

Many hours were spent in contemplation, fabrication and construction to evolve a seat (a "châise longue" *The Times* called it) which could fully recline whilst running on rails from the floor up the wall. This was deemed necessary as after thrust ceased the ship would be rotated slowly to provide a simulated gravity; then thought to be advisable if only for the benefit of much of the equipment on board (this was pre-transistor days).

My daughter's toy mangle was "modified" to produce curved lengths of corrugated aluminium walkways for space ships! Maybe she chattered too, for I often got strange looks from some of the villagers and veiled remarks as to when I was going and how long I would be away. They were quite disappointed when I explained it was but a scale model being made. It made an opportunity for a short lecture and a "plug" for the BIS. The rumour that it was for real was enhanced by the frequent arrival of large packing cases marked "Fragile - Machinery," "Rolls Royce Ltd," "Bristol Aerojet," "Avro," etc. The reason was that my house, at that time, was the home base for the then Society's Midlands Branch's growing collection of exhibition material which was loaned out all up and down the country.

Eventually the Life Compartment was deemed finished

The life compartment is now being considered for display in the astronautics section of The Science Museum in London.
The Science Museum



and joined the other visual aids and hardware with which we attempted to convince people in the 1950's that it *was* possible to go to the Moon, and to persuade them to join the BIS.

NORMAN NICOLL

The IAF Congress

Sir, It was a real pleasure to read the report on the IAF Congress in Budapest (*Spaceflight*, February 1984). I hope the whole UK delegation had a pleasant time in our country.

I was particularly impressed by the last paragraph describing your visit to the Satellite Geodetic Observatory, Penc. As the founder and first director of the observatory (from 1972 to January 1983) I am always pleased to read about it.

Spaceflight is my favourite source of information on every kind of space activity. It is always well informed, full of interesting news and technically correct. Congratulations!

IVÁN ALMÁR
President of the Hungarian
Astronautical Society;
IAF Vice President

Shuttle Radiators

Sir, Am I correct in thinking that *Challenger* does not carry radiator panels inside the forward half of the payload bay doors? On examining the photographs taken on STS-7 and mission 41B they cannot be seen, but as all the photos were taken from directly overhead it is difficult to be sure.

K.A. McNEILL
Edinburgh

Reply:

Challenger is no different from *Columbia* and does carry the radiators - if not, then other heat-rejection systems would be necessary. Once the bay doors are opened in orbit, the forward four panels (two each side) stand away from the doors by 35° and radiate waste heat from their upper and lower surfaces. The two panels towards the rear are attached to the doors and use only their upper surfaces to lose heat. If necessary, the aft quarter of the doors can also be fitted with panels.

Heat from electronics and other areas is transferred to the panels through Freon liquid circulating around the spacecraft. If the system cannot handle it, "flash evaporators" switch on to lose heat by boiling water away into space. This has to happen anyway when the doors are closed before reentry. The water handles the cooler part of reentry but then an ammonia boiling system cuts in to lend a hand down to the landing. There, ground vehicles supply coolant to stop the damaging heat of reentry seeping into the Orbiter's aluminium structure.

Funny Stories

Sir, Have you ever regretted, as I have, that space flight with all its achievements has failed to produce much of a repertoire or genre of humour? Jokes and humerous anecdotes about space are quite few and far between.

Why not solicit from the readers of *Spaceflight* brief anecdotes about rockets, astronautics, etc? The US Naval Institute does this very successfully in its *Proceedings*; its stories of ships and the naval service are perhaps the most read of all its contents.

GORDON VAETH
Washington, D.C.

Any offers? -ED.

Might-Have-Been Spaceship

Sir, A suitable addition to Mr. Non's collection of "Might-have been Spaceships" (*Spaceflight*, November 1981. p.330) appears in "Aventures Extraordinaires D'un Savant-Russe," written in 1899 by G. le Faure and H. de Graffigny, with a preface by Camille Flammarion.

Several booklets appeared, all concerned with expeditions to each of the planets in turn. As will be seen from the cabin of the starship "L'Ossipoff," reproduced below, everything was fitted out beautifully in the most attractive French fashion.

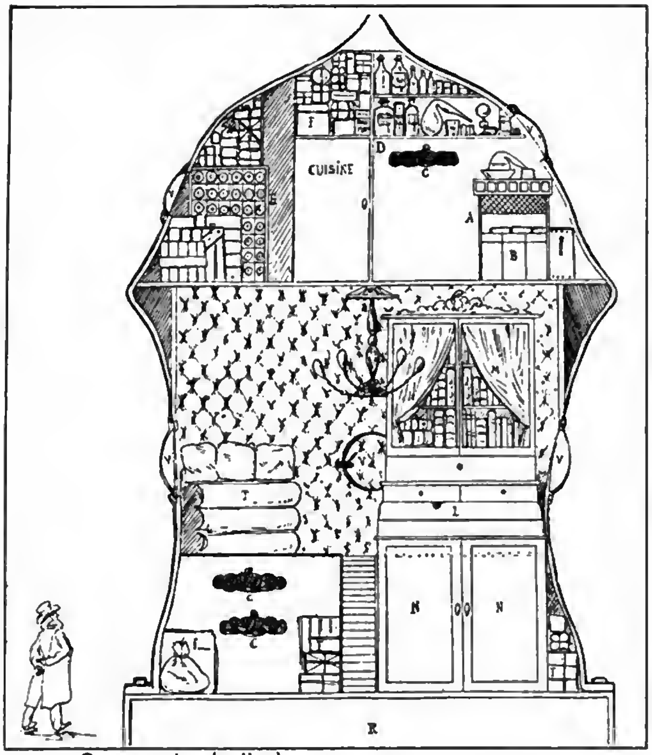
A key to the main areas, deemed essential for an adventure of this magnitude, roughly translated, is:

a. Laboratory.
b. Batteries.
c. Roll hammocks.
d. Chemical apparatus.
e. Oxygen cylinders.
f. Provisions and stores.
k. Electric Light.
l. Bureau.
m. Library.

DOWN UNDER

Society Fellow Jim James recently sent us some photographs and a covering letter telling us about Apollo astronaut Ron Evans' visit to Australia. Here they are, with Jim proudly displaying a BIS badge and tie. Ron was on the last Apollo flight to the Moon and was in Australia to present talks on his space experiences. Jim notes that at every lecture there was someone wanting to know how the astronauts went to the toilet in space! (Hopefully, they were not Society members).

A small mystery: Ron remembers vividly the time during Apollo 17 when he was flying on his own around the back of the Moon, only to be startled by his radio squawking "Whoop, Whoop." The cause was never found.



n. Commode (toilet).
r. Compressed air compartment.
v. Portholes.

M.W. WHOLEY
Midhurst, Sussex

Gemini and Pegasus

Sir, I recall somewhere that there was a plan back in the 1960's to rendezvous a manned Gemini capsule with a Pegasus satellite. What happened?

M.R. NAISMITH
Aberdeen, Scotland

Reply:

Three Pegasus satellites were launched carrying micrometeoroid detectors to investigate the threat posed by these high velocity particles to manned spacecraft. Pegasus 3 was put into a 530 km orbit in July 1965 with the possibility of a later spacewalk by a Gemini astronaut to recover materials mounted on the detector 'wings.' Gemini 6 was considered for this mission but the whole idea was dropped in January 1966.

True or False?

Sir, Mr. Non's letter claiming that he always had an audience of more than two (*Spaceflight* December 1983, p.467) is a travesty of the truth.

There is the matter of the Queen Mother's Garden Party held in the grounds of Clarendon House some years ago, to which he was invited with a view to addressing a distinguished audience on space matters in one of the Marquees. His audience, apart from the Chairperson, was exactly NIL.

How does he explain that?

L.J. CARTER

Mr. Non replies:

Modesty forbade me from mentioning this earlier simply because it is probably a World Record. Had it poured with rain that day, everyone would have crowded into the Marquee. Sadly it not only proved to be a glorious day but worse, the scheduled talk clashed with a Royal walkabout. Everyone went outside, including me.

SNIPPETS

Sir, Thank you for some splendid issues of *Spaceflight* recently. The new formet is very impressive.

DR. D.D. WYNN-WILLIAMS
Cambridge

Sir, Pleese allow me to congratulate the BIS on your sterling work. In particular, I am most impressed by the "new-look" *Spaceflight*, which complements an always-interesting content with a highly effective and professional-looking presentation in a manner which can only further the Society and its aims. As my modest contribution to the same worthy goel, please send me e couple of membership application forms, as I hope to recruit one or two new Members to our renks.

STEPHEN BRADY
8ucks

Sir, I em realiy proud to belong to the Society and I hope thet our 51st year will be as fine as our 50th.

STEPHANE PICCHIOTTINO
France

Sir, My compliments on the new issues of *Spaceflight*. The photographs and general artwork are e vast improvement - quite superb. The STS-6 article in the January issue was excellent. More of the same please.

STEVEN MADDOCK
8irmingham

Sir, I would like to take this opportunity to wish the 8IS well in 1984 and to congratulate you on the excellent quality of the publications. I regularly do lectures for astronomical societies and have found your publications to be of greet assistance es sources of information for topics which I heve covered, including exobiology, rocket propulsion and IRAS.

Thank you very much for your help.

M.J. LEGGETT

Sir, Thank you for the anniversary tie and the car badge, two very nice pieces of work. All I need is a Rolls-Royce to put the car bage on to do it justice.

DARRYL STICKLAND
California, USA.

Sir, May I appeal for the re-introduction of the Membership Card wallet? I thought it one of the handsomest items of BIS memorabilia, and certainly the most durable of any cerd-type wallet I've seen.

I felt it was well underpriced.

Each one of the novelty items produced by the Society is an asset to the membership drive. This particularly practical one deserves to be resurrected.

PAUL WINKLER
Alberta, Canada

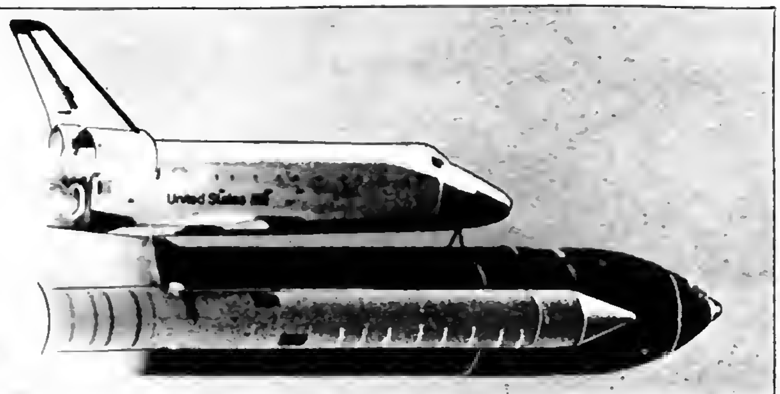
Sir, I wes intrigued by the ception to that fine representation of the Jovian system on page 78 of February's *Spaceflight:* "The median launch date for such a mission in the Delphi study was 2029 – only 35 years hence." According to my calculations, this is 1984 so the launch is 45, not 35 years hence. Mind you, since I am now 62, it is an academic point whether that epoch-making event is 35 or 45 yeers hence, since I'm unlikely to appreciate the differencel

JACK GORDON
Ruislip, Middx.

The Editor is elways interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

SPACE REPORT

A monthly review of space news and events



SPACE SHUTTLE

MISSION CANCELLED

As *Spaceflight* predicted on p.112 of the March issue, Shuttle mission 41E has succumbed to the problems of the Inertial Upper Stage. The IUS launched from *Challenger* in April 1983 during STS-6 failed to put the TDRS-1 communications satellite into the correct orbit because nozzle steering was lost. Since then, engineers have been working to solve the problem, with several test firings.

The STS-10 mission intended for last November was cancelled and the same payload - known only to be a military satellite destined for geostationary orbit - was moved to 41E next July. Mission 41H in September is now the next military IUS slot available and NASA's 51C in December is scheduled to carry the second TDRS satellite.

NEW ASTRONAUTS

The latest batch of NASA astronauts is now being selected after a series of interviews and tasks at the Johnson Space Center in February and March. The six batches of 20 candidates each spent a week at JSC as part of the process to pick about a dozen new astronauts. There was a total of 4934 applicants by the closing date in December (see *Spaceflight*, September 1983, p.347).

The new group - which will become NASA's 10th - will begin training in July before reaching astronaut status next year.

SHUTTLE WING SPOILERS?

One of the problems encountered by the Space Shuttle during launch is the lift generated by the Orbiter's wings. The craft needs all the lift it can get on the way down but during the trip into orbit lift alters the trajectory and actually cuts down on overall performance. This means the Orbiters can carry less cargo.

NASA are studying the possibility of adding 30 cm-wide 'spoilers' to the wings which would disrupt the airflow and destroy lift. During descent, they would be retracted to allow the air to travel smoothly over the aerodynamic surfaces.

Another problem affecting the Orbiters is debris from the External Tank and Solid Rocket Boosters during flight. Engineers have been working for some time to prevent ice building up on the ET walls as water condenses out of Florida's humid atmosphere on to the container with its supercold propellants. Chunks of it break off and damage the Orbiter's thermal protection tiles. That problem seems to be under control but another reared its head at the start of STS-9 last November. Debris from around the small motors that separate the SRBs was found imbedded in the recovered booster casings. The fear, again, is that the thermal tiles could be damaged. Analysis has shown the damage occurred well after separation - so the Orbiter was in no danger - but the offending bolts around the motors are being replaced.

ORBITAL FILM

A unique film camera, Cinema 360, flew aboard *Challenger* in February during mission 41B, the first of three trips for the camera to film Shuttle missions with a special lens.

The project is part of a "Joint Endeavor Agreement" between NASA and Cinema 360, Inc., a non-profit organisation that produces educational films for planetaria.

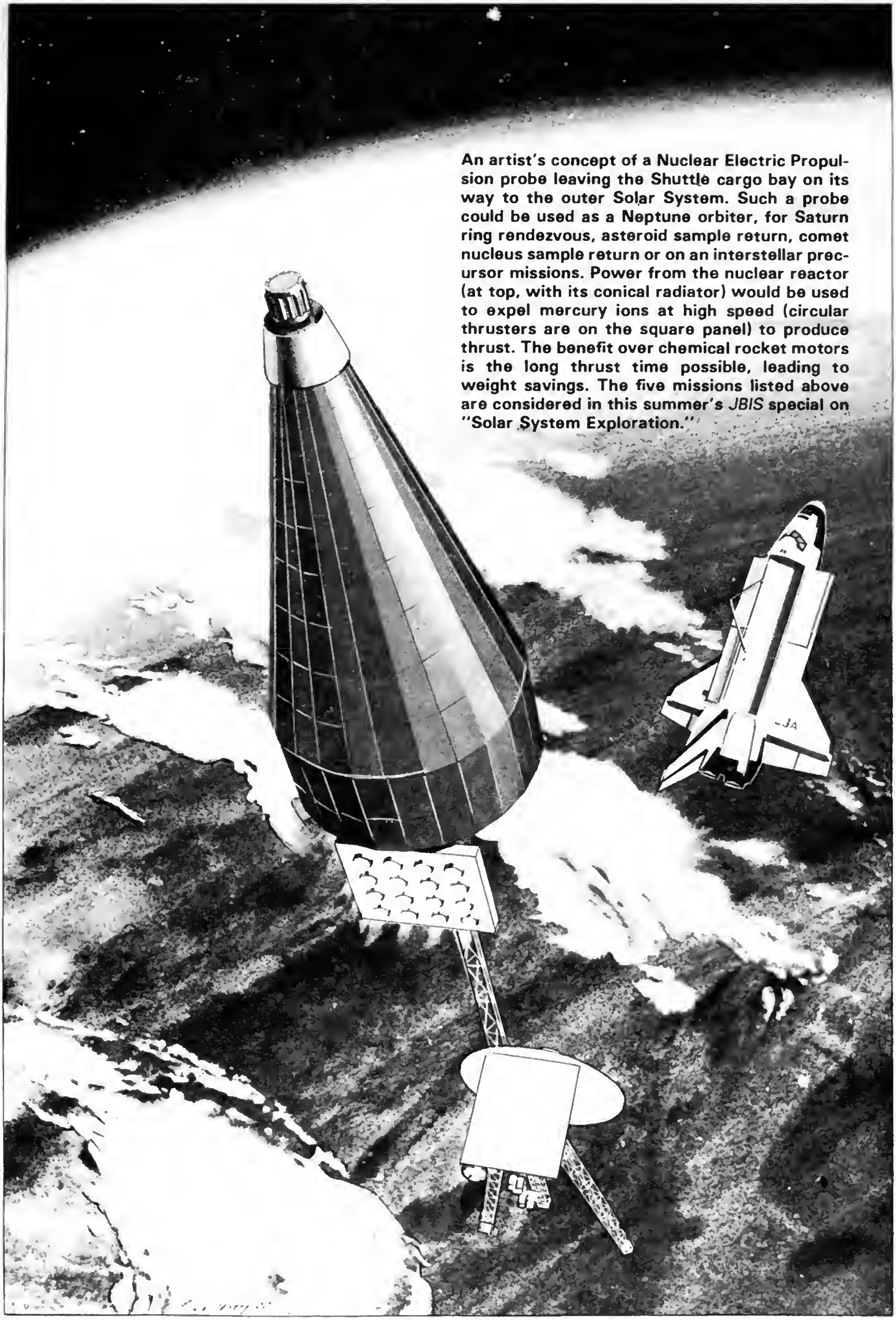
The format is designed for showing in hemispheric planetarium domes. An F/2.8 "fisheye" lens enables the camera to capture a 180° by 360° field of view. Footage from the three flights will be used in a 30 minute film entitled *An American Adventure*.

UPPER STAGE DELAY

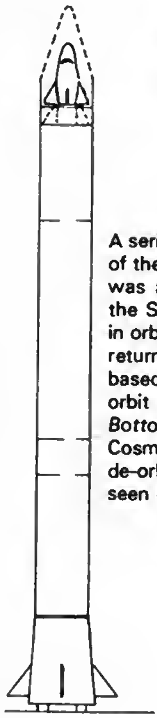
NASA's second Tracking and Data Relay Satellite (TDRS) will now have to wait until March 1985 before it can be launched because the Inertial Upper Stage will not be ready in time for the planned Shuttle mission 51C this December.

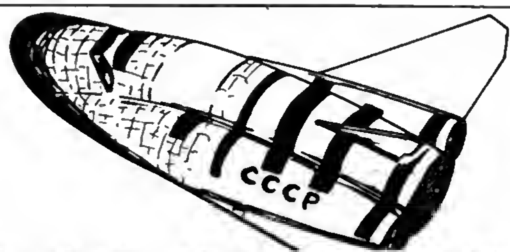
TDRS 1 was launched in April 1983 during flight STS-6 but the failure of the IUS second stage steering left it far below the required geostationary orbit. Ground controllers were able to use the satellite's own small thrusters to reach the correct orbit in time for the Spacelab 1 mission to use it as a data link. The cushion ('Techroll') around the nozzle was found to have failed and testing immediately began in improved versions. As a result of a ground firing on 2 December more heat insulation was added as protection from the hot nozzle and an altitude chamber firing on 3 March was used to eliminate environmental factors (vibration, vaccuum, etc). A third test in August should clear the IUS for flight, but not in time for a December launch.

When TDRS 1 went up in April 1983 the second and third satellites were due to follow in August 1983



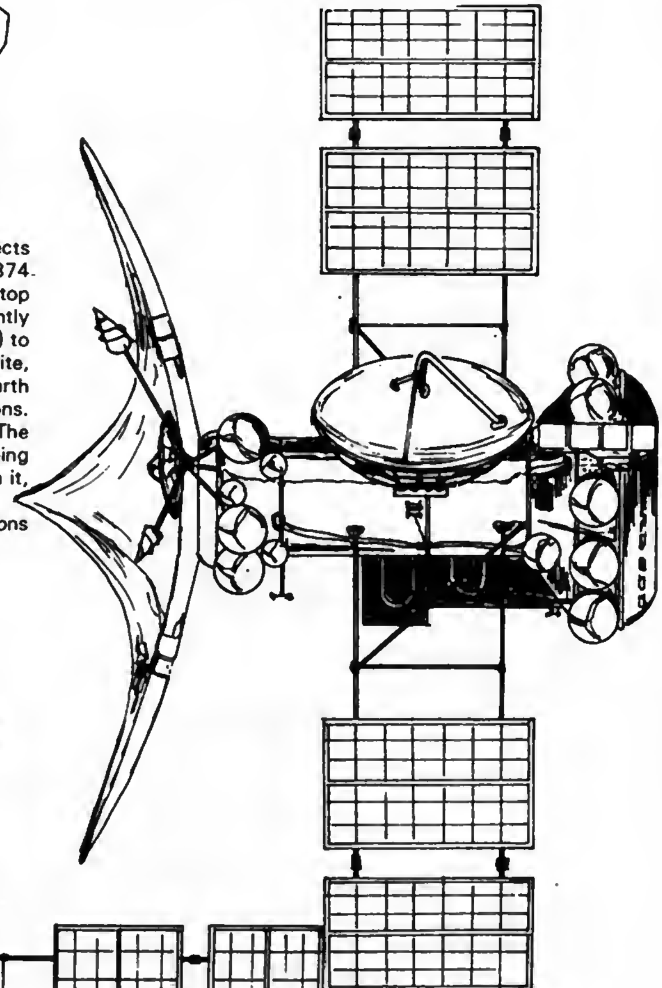
An artist's concept of a Nuclear Electric Propulsion probe leaving the Shuttle cargo bay on its way to the outer Solar System. Such a probe could be used as a Neptune orbiter, for Saturn ring rendezvous, asteroid sample return, comet nucleus sample return or on an interstellar precursor missions. Power from the nuclear reactor (at top, with its conical radiator) would be used to expel mercury ions at high speed (circular thrusters are on the square panel) to produce thrust. The benefit over chemical rocket motors is the long thrust time possible, leading to weight savings. The five missions listed above are considered in this summer's *JBIS* special on "Solar System Exploration."

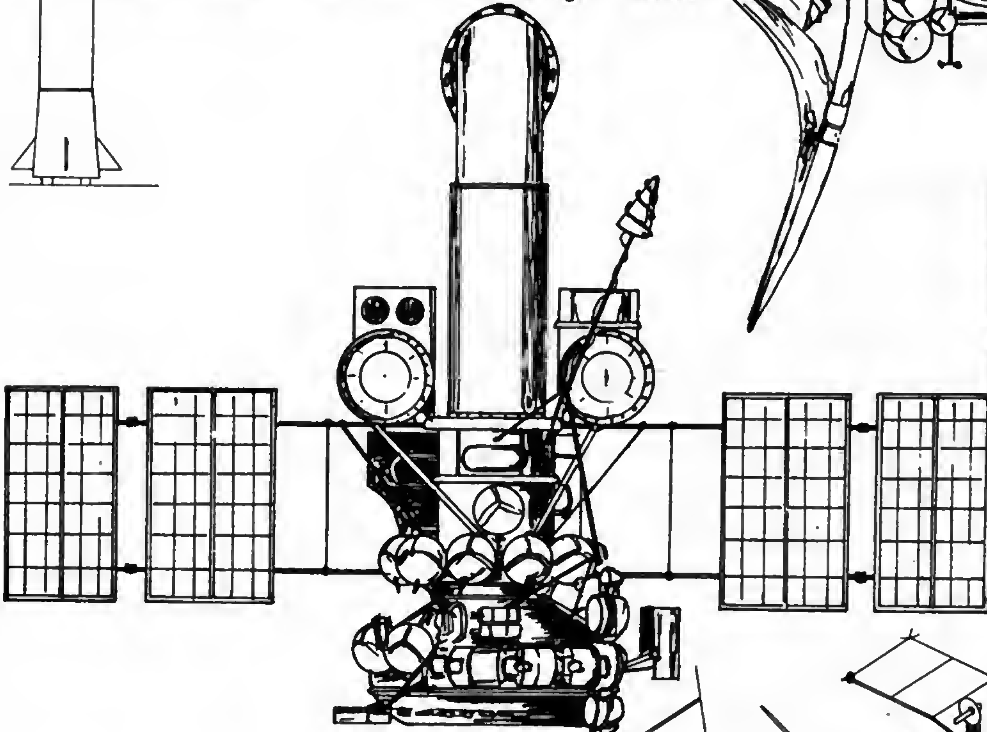


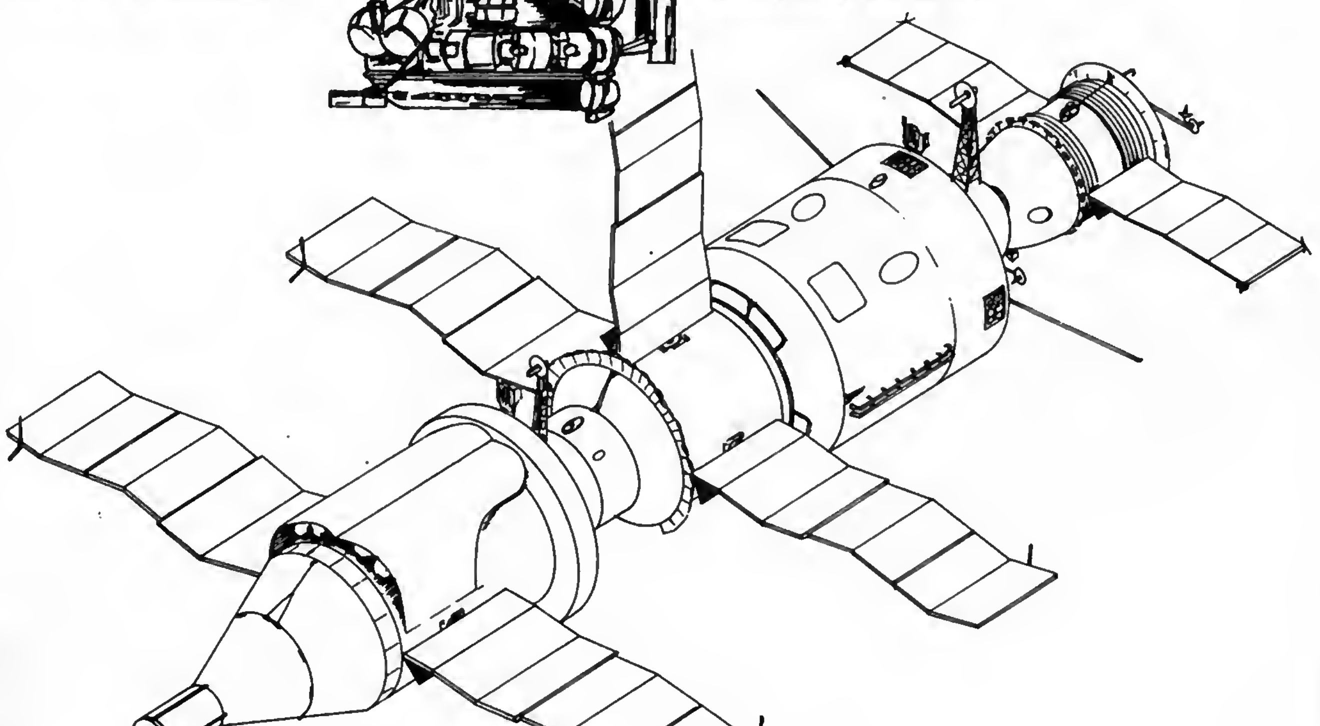


A series of drawings by Ralph Gibbons illustrate various aspects of the Soviet space programme. *Left and above:* Cosmos 1374 was a scale model of the small Soviet shuttle launched atop the Skean SL-8. *Right:* the Venera 15/16 craft are presently in orbit around Venus using their radar (antenna seen at left) to return surface images. *Below:* the Astra astronomical satellite, based upon the Venera spacecraft, was launched into Earth orbit in March 1983 for X-ray and ultraviolet observations. *Bottom:* (from left) Cosmos 1443, Salyut 7, Soyuz T-9. The Cosmos "Star" module remained aloft for 201 d, finally being de-orbited on 19 September 1983. A descent module from it, seen extreme left, was recovered on 23 August.

All drawings R. Gibbons







(STS-8) and March 1984 (STS-12). The failure forced STS-8 to fly without a major payload and STS-12 was cancelled, with the crew transferring to STS-14 (Mission 41D) this June.

SPACELAB 3 POWERED UP

Spacelab 3 moved a step closer to its seven-day November mission when power was turned on for the assembled experiment payload for the first time in March.

"Each of the instruments was first checked out individually and then tested as they will be operated as a payload during the mission," explained mission manager Joe Cremin of the Marshall Space Flight Center. Testing was done for Marshall, the Spacelab managing centre, by technicians at the Kennedy Space Center in Florida.

The experiments were joined to simulated Spacelab support subsystems while, later in the spring, the instrument racks were due to be installed in the habitable module. The special support structure for experiments requiring direct space exposure will be moved into place behind the module. The payload will then be connected to the actual Spacelab subsystems for further testing.

Meanwhile, members of the payload crew are continuing their preparations to operate mission experiments. Crew members returned in March from France from training with the Very Wide Field Camera and Mercuric Iodide Crystal Growth experiments. "It was a valuable experience," said Dr. Mary Johnston, one of four payload specialists in training. "We worked directly with the principal investigators (scientists) and members of their research teams, and we trained on engineering models of the two experiments."

Spacelab 3 will be the second flight of the ESA-developed laboratory and its first operational mission. It will consist of a long module in which the scientists will work and a support structure for cargo bay-mounted experiments. The research work includes materials science, life sciences, fluid mechanics, atmospheric science and astrophysics.

STRUCTURAL ASSEMBLY TEST

In May 1985 a structural assembly test called "EASE" - Experimental Assembly of Structures in EVA (Extravehicular Activity) - will provide fresh insight into the ability of humans to work in space.

Essentially, the Mission 51G experiment involves six aluminium beams, each 3.6 m in length and 10 cm in diameter, in the Shuttle payload bay. The beams will be assembled and disassembled several times by a team of two astronauts in space suits.

"Astronauts will demonstrate the performance of human beings in orbit as they attempt to build strong, practical structures," said Large Space Structures study manager Jim Harrison of the Marshall Space Flight Center.

NASA/3M AGREEMENT

The US 3M company are to begin a long-range basic research programme in space with the aim of producing, eventually, commercial products in orbit. The initial experiments dealing with organic crystalline materials and the preparation of thin film that could be used in electronics, imaging, energy coversion and biology could be ready to fly aboard the Space Shuttle by August.

Declaring NASA to be "delighted," Administrator Beggs said the agency "stands ready to assist in this initiative." The two organisations, he said, "have agreed to work together to develop a plan to explore the space frontier for potential commercial applications in materials processing. On the basis of studies leading to the research programme, 3M has advised NASA to consider establishing a series of Advanced Research Institutes. These would coordinate the work of industry, government and academic institutions in basic long-term research that could lead to successful commercial products.

LOW COST SHUTTLE EXPERIMENT

The "Hitchhiker" low cost experiment carrier will now fly on the Shuttle in an altered form, writes Joel Powell. Intended to fly as early as this August with ultraviolet photometers, a military plasma physics experiment and the MIT structural assembly experiment (involving a space walk), these experiments will now use Getaway Special canisters, and Hitchhiker will be reformed as two experiment carriers. The first will use the MPESS (Mission Peculiar Experiment Support Structure), first flown on STS-7, and the second will be a mount on the sill of the cargo bay to be called SPOC (Shuttle Payload of Opportunity Carrier). They should be ready for use by late 1985.

ORBITAL TUG TEAM

As reported on p.158 of the April issue, NASA are selecting companies to perform studies for a 'smart tug' for use with the Shuttle. Aeritalia of Italy and the US Boeing company have joined to produce a concept for an Orbital Manoeuvering Vehicle (OMV). The Italian company would design the soft docking equipment.

As proposed by NASA, the OMV would be an unmanned, Shuttle-launched, reusable upper stage for delivering and retrieving payloads to and from orbits beyond the Shuttle's reach. It would rendezvous and dock with other spacecraft, controlled from a ground station using TV and radar systems.

Aeritalia has been developing designs for reusable docking joints for orbital assembly of modular spacecraft which can be applied directly to the OMV. The company has also started tests on full-scale soft-docking hardware.

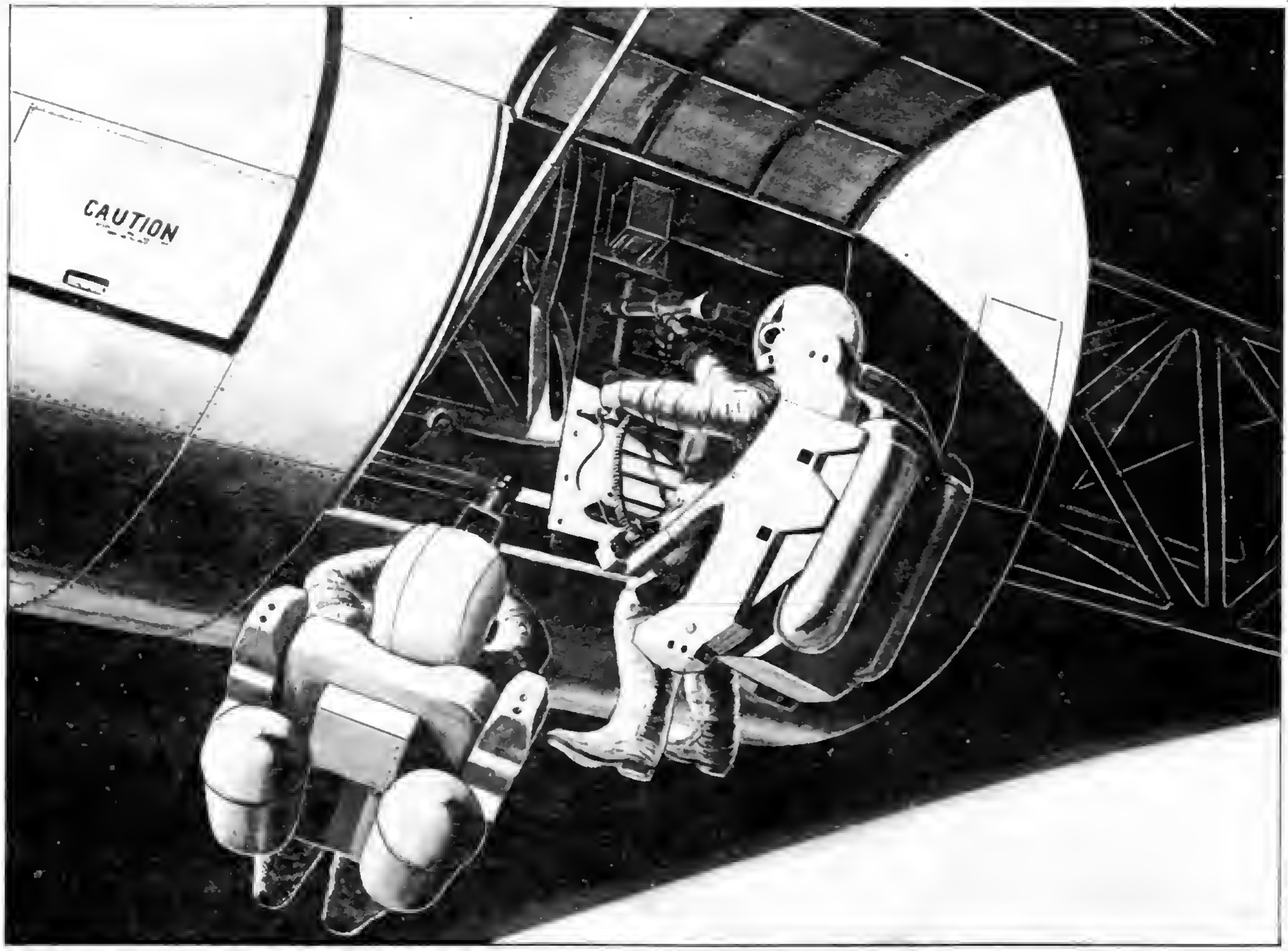
SPACELAB D-1

The German-sponsored Spacelab D-1 flight in September 1985, the third orbital trip for *Atlantis*, will carry eight crew members; three have now been named. Bonnie Dunbar and Guion Bluford (veteran of STS-8 in August 1983) will be mission specialists. Stephen Nagel, who will first fly aboard mission 51A next October, will be one of the three pilots. Normal Shuttle trips carry only two but Spacelab places heavy demands on their time - the Spacelab 1 team had to work 12-hr shifts.

REFUELLING TESTS

Trials to test if it is possible to refuel the Shuttle-carrying 747 aircraft in flight were halted in February because of cracks found in the 747's tail.

At present, the Jumbo has to interrupt ferry trips back to Cape Canaveral with a Shuttle Orbiter on its back in



The complex work undertaken by the Shuttle astronauts with the Solar Max satellite in April paves the way for man-based orbital construction. This artist's concept shows two astronauts with manoeuvering backpacks working on a large space structure. *Martin Marrietta*

order to pick-up more fuel. The problem would be even more severe if the spacecraft had to make an emergency landing outside of North America.

The first two of nine tests used USAF KC-135 and KC-10 aircraft flying above and in front of the Jumbo. In operation, a refuelling line would link up to the carrier's tanks. The cracks are thought to have been caused by turbulence from the overhead 'planes; engineers are now concentrating on devising a scheme for the tanker to fly below and behind.

The 747 was without a Shuttle at the time of the tests.

SHUTTLE LAUNCH POLICY

Customers wanting to launch cargoes aboard the Shuttle must now pay $100,000 'earnest money' for *each* payload. In the past, customers have fowarded *multiple* payloads in a series for a single $100,000 payment. This produced a launch manifest containing many cargoes unlikely to fly, affecting NASA's planning for customers with well-defined requirements.

The money will now be applied to the first progress payment for each payload or will be kept by NASA if a Launch Services Agreement is not signed.

SPACEWALK RADIOS

When a spacewalking astronaut uses his manoeuvring backpack to leave the Shuttle Orbiter his one link to the world is a small UHF radio. "This is the ultimate reliability test for these highly-reliable radios," said Paul Shack, NASA subsystems manager at NASA's John Space Flight Center in Houston.

Built by RCA, the radios are about the size of a loaf of bread and weigh 4 kg. Similar versions are installed in the Orbiter's cockpit to complete the communications link. The radios also provide a number of other services. The backpacks, for example, send telemetry signals of the astronaut's heartbeat, and deliver "caution" and "warning" signals when life-support systems are running low.

For reliability, each radio has two transmitters and three receivers. If one system fails a spare can be selected quickly. (The cockpit radios each have three transmitters and four receivers).

SATELLITES

INTELSAT DELAY

The launch of the eighth Ariane on 5 March was delayed because of problems with the Maritime Communications Subsystem aboard the Intelsat 5 satellite payload.

Of the 15 satellites in the 5/5A series, five (numbers 5 to 9) are being equipped for maritime communications. The first three MCS are now leased and operated by the International Maritime Satellite Organisation (Inmarsat) in the Atlantic and Indian Ocean Regions.

"Adding to the MCS package to the already complex Intelsat 5 has not been an easy task," according to

Intelsat's Director General, Richard Colino. "After the first two had been launched and become operational we started experiencing occasional noise bursts in the transmissions from the MCS."

To a user of the maritime telephone service, the only effect of this is that there are brief occasions when the level of background noise and the delay in getting a dial-up connection are greater than normal.

"The problem meant that we had to delay the launch of the third MCS-equipped satellite (Intelsat 5 F-7) while a team of experts conducted an investigation and devised some modifications," Colino said. "Unfortunately these were not successful and we also had to delay the fourth MCS on Intelsat 5 (F-8) while experts from Intelsat and the satellite's manufacturer went back to their drawing boards.

"Intelsat could not delay the launch of this satellite any longer. It was needed to replace an ageing satellite. Moreover, any further delay would have had a domino effect on Ariane's subsequent launches for other orgnisations."

The final six satellites of the series will be the 5A version with a capacity to handle 15,000 simultaneous telephone calls - 3,000 more than the earlier model. Beginning this year, American Atlas Centaurs will launch four of them, with Ariane 2 launchers handling two in January and May 1986.

LAUNCH POSTPONED

Launch of the Hughes Company's Galaxy Communications satellite, originally set for May, was postponed in February because of the loss of the two similar satellites from Shuttle mission 41B. The satellite was to have been orbited by a Delta rocket from Florida using one of the suspected Payload Assist Modules. Both PAM nozzles are believed to have failed in the Shuttle launchings.

The US Air Force decided in February to go ahead with the launch of their latest Navstar navigation satellites in April and August aboard Atlas E rockets from Vandenberg Air Force Base in California. Each launch uses two Star 48 motors, the same type as used in the PAM systems. The Air Force say, however, that their motors are from a different batch than the two Shuttle stages. The problem is thought to be a manfuacturing one and not the design itself.

EUROPEAN SATELLITE CENTRE

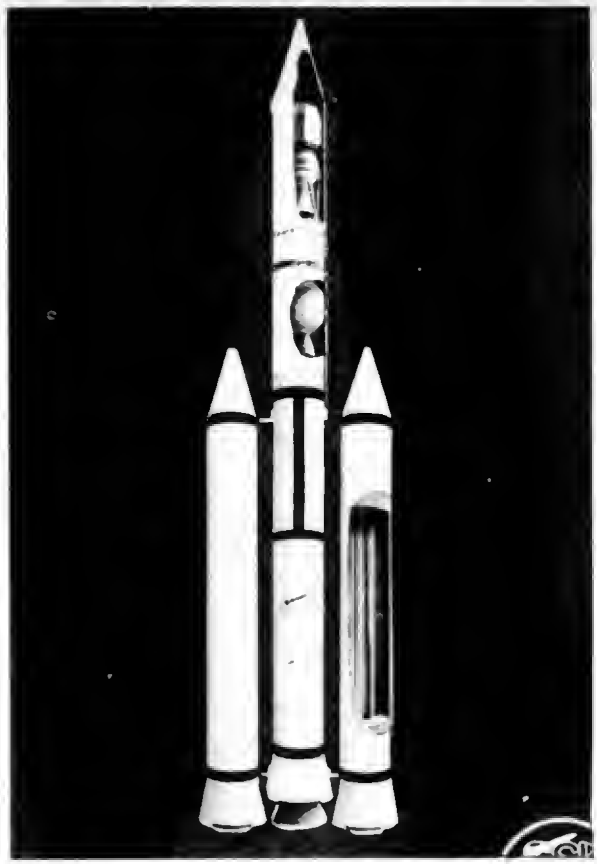
Bulgaria has become the first country in Europe to have a Rescue Co-ordination Centre equipped for maritime satellite communications. With its newly-commissioned ship Earth stattion, the RCC is able to contact vessels in seconds in emergencies.

The RCC, at Varna on the west coast of the Black Sea, now has direct access to the satellite system operated by the International Maritime Satellite Organisation (Inmarsat), of which Bulgaria is a member. Forty countries in all are members of the London-based organisation.

NEW ECS SATELLITES

Eutelsat, the organisation of European national Post and Telecommunications agencies, is issuing requests for proposals for a new series of ECS satellites to begin operations in 1989. ECS-1, with its capability for 12,600 voice links, is already in orbit and numbers 2 and 3 are due for launch by Ariane in July this year and August 1985, respectively.

The new ECS-A series will act as intermediate satellites until more advanced technology becomes available in the 1990's.



An artist's impression of Space Services Inc.'s Conestoga 2 launcher, now under development. The Houston-based company plans to market the vehicle as a commercial enterprise. Paul Maley, who kindly supplied this illustration, will describe the enterprise in a forthcoming issue. *SSI*

NASA/ITALIAN AGREEMENTS

NASA and the Italian National Research Council (CNR) have signed two agreements to establish the development of the Tethered Satellite System and the development and launch of the Laser Geodynamics Satellite 2 (Lageos 2).

The 500 kg TSS will be carried into orbit by the Shuttle and released from the payload bay on a tether, reaching up to 100 km from the Shuttle. CNR will build the satellite for a first launch in December 1987.

The tethered satellite can be used for sampling the upper atmosphere, for example, or for electrodynamic research on space plasma.

Lageos 2 will help us to understand the solid Earth and its dynamic processes. It will be indentical to Lageos 1 (launched in 1976 by NASA) and will be placed in an orbit of similar altitude but with a different inclination (51-53° prograde instead of 70° retrograde). The 60 cm sphere will weigh 411 kg and be covered in laser reflectors.

It will aid studies of plate tectonics and the accumulation of crustal strain in areas of high seismicity (such as the Mediterranean) through very accurate measurements of baseline changes resulting from crustal motion. The two satellites, in essentially opposite orbits, will improve

the precision of current laser-determined baselines by a factor of two and will allow a precision of 1 cm for baselines of several thousand kilometres.

CNR will build the satellite and its upper stages and NASA will provide the Shuttle for a 1987 launch.

OCEAN SATELLITE

Eight-month contracts for definition studies for Topex, a NASA oceanographic satellite, were awarded in March to Fairchild Industries, RCA Corp. and Rockwell International. Fairchild's Multimission Modular Spacecraft, RCA's Advanced Tiros N satellite and Rockwell's Global Positioning System satellite are all candidate designs to save a costly new design being used.

Topex will provide at least three years of detailed ocean topography information, beginning in 1989, for determining global ocean circulation. NASA and the French space agency (Centre National d'Etudes Spatiales) have discussed how they might conduct a joint ocean circulation mission and subsequent science investigations. NASA is therefore studying two options: a joint Topex/Poseidon mission and a US only mission. If the French are involved then the Ariane 4 launcher would be chosen instead of the Shuttle.

ESA SATELLITE MOVED

With the growing number of satellites in the geostationary orbit, 36,000 km above the equator, the increasing risk of collision between working and deactivated satellites has to be faced. This orbit is vital for communications and weather satellites. The only practical control is to remove satellites once they have reached the end of their useful lifetimes. ESA recently carried out such a move with GEOS 2. Launched in 1978, with a planned life of two years, GEOS, designed to measure electric and magnetic fields as well as particle streams in the magnetosphere, proved such a valuable tool for scientists that its mission was extended until the end of 1983. Its work came to an end as the fuel supply for orbit and attitude control ran out.

On 24 and 25 January, the European Space Operations Centre in Darmstadt, West Germany boosted GEOS into a higher orbit where it will present no risks either for satellites in the geostatinoary orbit or for those in transfer orbit. The orbit was raised by 270 km, somewhat less than planned due to thruster under-performance. GEOS will continue to drift around the Earth every 108 days in its new orbit, having freed a location in the all-important geostationary orbit. If desired, scientific data could still be received during the limited periods of contact with the ground station.

This is the first time that ESA has decommissioned and removed one of its satellites from the geostationary orbit. The success was to be repeated with another ESA craft, OTS 2, also destined for a higher orbit.

CHINESE ORBITAL LAUNCH

On 29 January the launch of PRC-12 took place. The Chinese launch announcement simply said that important results had been obtained from the mission.

The main object, 1984-008A, made some interesting changes to its orbit, writes P.S. Clark. At about 19.00 GMT on 30 January (if the orbital data are correct) this object manoeuvred from a 307-449 km orbit to a new

The Lageos 1 satellite was launched in 1976 and is still being used for laser ranging work. *NASA*

36.03°, 160-80 min, 359-6,475 km orbit. This took place some distance from the equator and the delta-V totalled 4,975 m/s.

The launch of PRC-12 seems to have introduced two new elements to the Chinese space programme. The first is the long-awaited three stage Long March 3 booster, with the third stage using liquid oxygen and liquid hydrogen. This new stage performed the orbital injection and the large orbital manoeuvre. On later missions, it will be used to place communications satellites in geostationary orbits.

The second is a new launch site. It is not possible to pin-point the new site from one mission but is must lie within the area 20°–31°N, 103°–120°E, with the more westerly part of the area most probably containing the launch site. The launch time for the mission was about 10.50 GMT.

One would expect that the geostationary Chinese missions will be launched from the new, more southern launch site rather than from Shuang-Ch'eng-tzu, since the new site allows a lower inclination parking orbit to be used, which in turn allows the same booster to orbit more payload.

TEAL RUBY SATELLITE

The US Air Force Teal Ruby (P80-1) satellite, originally scheduled for launch on STS-10 in late 1983 before a combination of development problems and the IUS upper stage accident with TDRS in April 1983 delayed the mission, has been reprogrammed by the Air Force for a Shuttle launch from Vandenberg Air Force Base, writes Joel Powell. The spacecraft was also redesignated as AFP 888. Teal Ruby may now fly as early as October 1985, the first Shuttle launch from Vandenberg. An onboard hydrazine system will boost it to an operating altitude of 741 km where it will track aircraft with a large 'staring' mosaic focal plane infrared array for a year. Auxiliary payloads include an extreme ultraviolet astro-

nomical experiment, a NASA ion engine for station keeping tests (after depletion of Teal Ruby's cryogenic coolant) and a US Navy stellar horizon atmospheric dispersion experiment, replacing the Lasercom communications payload.

WEATHER SATELLITE

The seventh in a series of 10 US Air Force Block 5D weather satellites became operational in late 1983. The satellites provide weather information to the US military services.

Developed and built by RCA Astro-Electronics for the US Air Force Space Division, the advanced Block 5D-2 weather satellite was launched by an Atlas vehicle on 17 November last year. The first 5D-2 was orbited on 20 December 1982.

Block 5D-2 satellites are designed for mission lifetimes of three years - half longer than their predecessor Block 5D-1 craft. The satellites are 10 cm longer and have a 25 per cent larger solar array to allow for a larger payload. They are also "smart" spacecraft, controlled by on-board computers that can be reprogrammed to handle diverse tasks.

ASAT TARGET LAUNCH

The first launch of a target balloon (payload AF-16) for the US Air Force anti-satellite system has been set for the fourth quarter of 1984, likely in December, writes Joel Powell. A Scout rocket will launch ITV 1 (Independent Target Vehicle 1) from Wallops Island in Virginia; the first test firing of the ASAT was made on 21 January 1984 from Edwards Air Force Base in California.

OTHER NEWS

SPACE STATION CENTRE

NASA's Johnson Space Center in Houston, has been named as the "lead centre" for the agency's new Space Station Programme, NASA Administrator James Beggs announced in February.

In a letter to centre director Gerald Griffin, Beggs said that he was requesting the centre to form a programme office to execute five basic responsibilities: Systems Engineering and Integration, Business Management, Operations Integration, Customer Integration and Support of NASA Headquarters Space Station Program Office.

Beggs also requested other NASA centre directors to assist in the development of a detailed functional plan for the new management and directed Headquarters and other centres to recommend key personnel to help in the detailed planning and staffing.

Beggs also noted that he plans to form a new organisation at NASA Headquarters in Washington to direct the programme. The Center assignments are:

- Attitude Control and Stabilization System. Marshall is the lead centre of a team including JPL and Johnson, with Langley in a supporting role.
- Data Management System. Johnson leads Goddard and KSC, with support from Ames and the National Space Technology Laboratories, JPL and Langley.
- Auxiliary Propulsion System. Marshall leads Lewis, JPL and Johnson.
- Environmental Control and Life Support System. Johnson working with Ames.
- Space Operations Mechanisms. Marshall leads JPL, Johnson, Lewis and Marshall, with Langley in a supporting role.
- Thermal Management System. Johnson leads Goddard, Johnson, Lewis and Marshall.
- Electric Power System. The inter-centre team is Johnson, Lewis and Marshall, with JPL supporting. The lead centre will be designated later.

ARIANE LAUNCH SCHEDULE

The launch list for Europe's Ariane satellite carrier over the next three years shows that the vast majority of payloads are communications satellites. The only other satellites in the list here - correct as of March 1984 - are Giotto (Halley's comet probe), SPOT (French remote sensing) and Viking (Swedish magnetospheric experiments).

The updated Ariane 3 version will be introduced in the V10 launch - note the double payload - while the Giotto probe will use the old Ariane 1 left over after the Exosat astronomical satellite was transferred to a US Delta.

The Ariane 4 model is due to be introduced in March 1986 with V22. Note that 'V' numbers are now used to designate launches instead of the old 'L'. The launches after V23 are reservations only and not firm contracts.

		Type	Payload
1984			
May	V9	1	Spacenet 1
Jly	V10	3	Telecom 1 + ECS 2
Sep	V11	3	Marecs B2 + Gstar 1A
Nov	V12	3	Arabsat 1 + Spacenet 2
1985			
Jan	V13	3	Telecom 1B or SBTS-1 + Gstar 1B
Mar	V14	3	SBTS 1 or Telecom 1B + Spacenet 3
May	V15	1-2	SPOT 1 + Viking or Intelsat 5
Jly	V16	1	Giotto
Aug	V17	3	SBTS 2 + ECS 3
Sep	V18	2	TV Sat
Oct	V19	2-1	Intelsat 5 or SPOT/Viking
Nov	V20	2	TDF 1
1986			
Jan	V21	2	Intelsat 5A-F15
Mar	V22	4	Ariane 4-01, test
May	V23	2	Intelsat 5A-F13
Jun	V24	3	Flight opportunity
Aug	V25	4	Unisat 1 + opportunity
Nov	V26	3	STC + opportunity
Dec	V27	4	Intelsat 6

RENDEZVOUS WITH HALLEY'S COMET

Owing to the likelihood that Halley's Comet will prove to be a disappointing object when viewed from the Northern Hemisphere, if it can be seen at all, the Society plans to organise a trip to South Africa to view the comet from the Southern Hemisphere. Present indications are that the most favourable time will be the first week in April 1986. The provisional itinerary is: flight from London to Johannesburg, four nights in Johannesburg, three day tour of Kruger National Park, flight to Port Elizabeth, three day tour of the Garden Route from Port Elizabeth to Cape Town, four nights in Cape Town, and return to London *via* Johannesburg. There will be plenty of opportunities for viewing the comet.

The approximate cost at present day prices is £1,000. This includes all air and coach travel, accommodation in first class hotels, plus breakfast and dinner on coach-travelling days.

Forms for provisional registration are now available from the Executive Secretary. Please enclose a stamped addressed envelope.

A deposit of £30 per person is required, fully refundable on written cancellation at any time up to December 1985.

ARE YOU MISSING OUT . . .

. . . on the information and excitement of *Space Education?*

The first of this year's *Space Education* issues includes a range of articles on the teaching and philosophy of astronautics, as well as 'hard' space information.

Professor Bettye Burkhalter *et al* describes the world's largest space camp for children, while Paul Maley and Geoffrey Perry discuss space activities that are not only educational but fascinating to carry out.

An amateur space telescope for launch aboard the Shuttle is described by one of its managers and details on how the astronauts actually cope aboard the reusable spacecraft are presented in "Living aboard the Space Shuttle."

European work in remote sensing is covered, while Frederick Ordway concludes his series on collecting space books.

Copies of *Space Education* are available at £2 ($4) each, post free from The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ.

The Library Committee is endeavouring to build up its collection of first-day covers on

SPACE AND ASTRONOMY

We would welcome hearing from any members with items like this for disposal and willing to give or sell them to the Society.

All manner of items will be considered but the Society has a particular interest at present in securing covers ranging from pre-war launchings to the manned Mercury and Gemini flights.

Please contact the Executive Secretary if you think you can help.

MAY 1984 *JBIS*

The latest "Space Chronicle" issue of *JBIS* contains an array of papers describing space projects from the 1950's to the present day.

"The Chinese Space Programme" is a comprehensive survey by P.S. Clark of Chinese accomplishments in astronautics. H.J.P.Arnold describes the first photographs taken outside a spacecraft (Edward White in June 1965) and explains why most of them have never been seen publicly. The early US launch vehicles Thor Able and Atlas Able are covered by J.W. Powell, who also contributes a paper on "add-on" satellites carried by Delta rockets.

M.J.F. Fowler completes his survey of the Spacelab 1 life sciences experiments and J. Richelson looks at the SDS satellites.

Copies of *JBIS* are available at £2 ($4) each, post free, from The British Interplanetary Society, 27/29 South Lambeth Rd, London SW8 ISZ.

SPACE NEWS is a bi-weekly newsletter on astronomy and space science. Subscriptions are $7.50 per year (26 issues) or $13.00 for two years, in the US. European subscriptions are $16.50 per year, $30.00 for two years, sent by Air Mail. Order from: Space News, PO Box 66521, Baton Rouge, LA 70896, USA.

ASTRO INFO SERVICE: 26 High Farm Road, Hurst Green, Halesowen, West Midlands B62 9RX, England: for latest list of publications, STS embroidered emblems, mission highlight cassettes and a new bi-monthly magazine *Manned Spaceflight News,* contact Dave Shayler at the above address.

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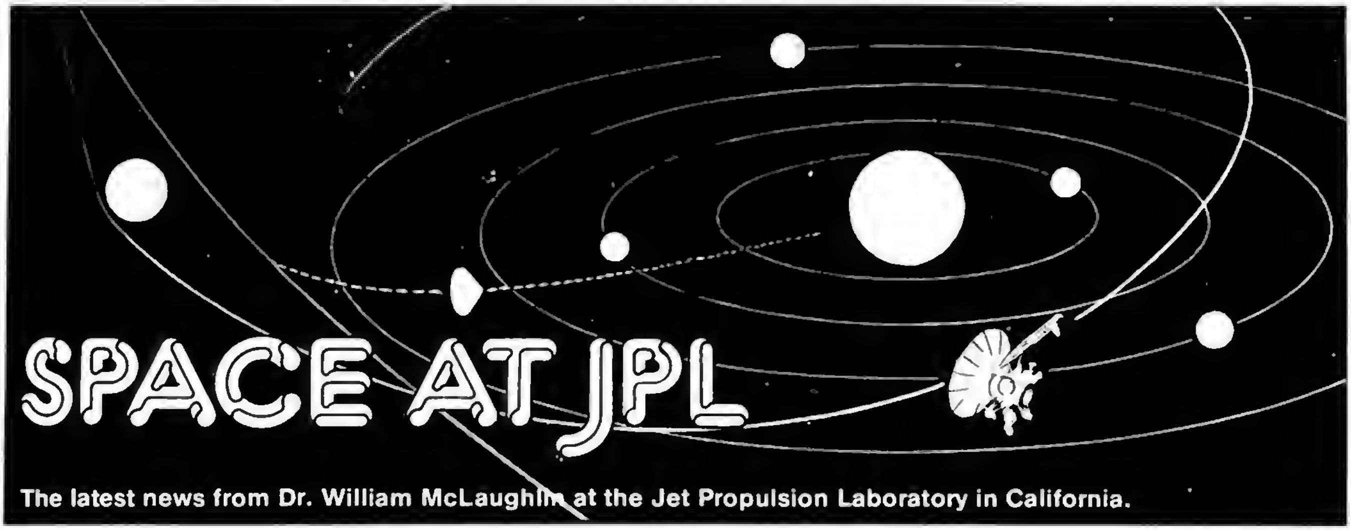


QUASAT MISSION

In the opening years of the 19th century Thomas Young demonstrated the wave nature of light by means of the phenomenon of interference. Light waves from a source reinforce or cancel one another to produce bright/dark patterns on a display screen after passing through small holes in a screen. The form of the pattern depends upon the nature of the source and the differing path lengths which the 'wave trains' cross before reaching the screen.

Science has found frequent employment for interference: one particularly efficacious use being embodied in the modern interferometer. In radio interferometry two or more radio antennae, physically separated but electronically connected, observe the equivalent of interference patterns from which the structure of the radio emitter may be deduced. Radio astronomy has used interferometry to discover fine details in distant galaxies which cannot be resolved in any other fashion.

Since the resolution of an interferometric measurement increases with increasing distance between the arrayed antennae (Very Long Baseline Interferometry or VLBI), achieving about a milliarcsecond - or about two-hundred-thousands of a degree - for the largest baselines on Earth, it is natural to seek to place one component antenna of the interferometer in space in order to achieve even greater resolution by means of an extended baseline. Thus, the Quasat mission, which is featured as this month's advanced concept review, has been proposed by an international team of scientists jointly to NASA and ESA. It is not currently funded as a project. The mission would use a 15 m antenna in Earth orbit in a cooperative fashion with US, Canadian, European and Australian radio telescopes to study quasars, the nuclei of radio galaxies and other astronomical objects emitting in the radio range to an unprecedented degree of resolution: five times greater than that attainable from Earth.

The orbiting antenna will be deployed after launch and conduct an observing programme at 1.35 cm, 6 cm and 18 cm wavelengths with a submilliarcsecond resolution. Something like 1,000 to 10,000 extragalactic sources should be within the capability of this observing system which, typically, will require about 24 hours per observation. The supporting satellite, either three-axis stabilised or a spinner, must be able to point the antenna to an accuracy of about ± 1 arc minute, somewhat less than the accuracy requirement for the IRAS telescope pointing. Total mass in orbit is estimated to be a modest 800 kg.

The orbit for this two or three year mission is planned to have an apogee of about 15,000 km and a perigee of 4,000 km. The high apogee will provide a long baseline for increased interferometric resolution, while the lower perigee assures that the intermediate-length baselines which are necessary to fill in the synthesised aperture of the system are available. The orbit will be inclined from 45° to 65° to the Earth's equator so that north-south baselines are established; east-west baselines for interferometry are yielded by the span of the orbit itself.

Follow-ons to Quasat might include a 50 m antenna for greater sensitivity so that more objects could be studied. A second type of follow-on mission would establish multiple satellites in orthogonal orbits out to 10^5 or 10^6 km in order to get very high angular resolution, approaching the microarcsecond level. Then phenomena associated with black holes in galactic nuclei would become accessible for study.

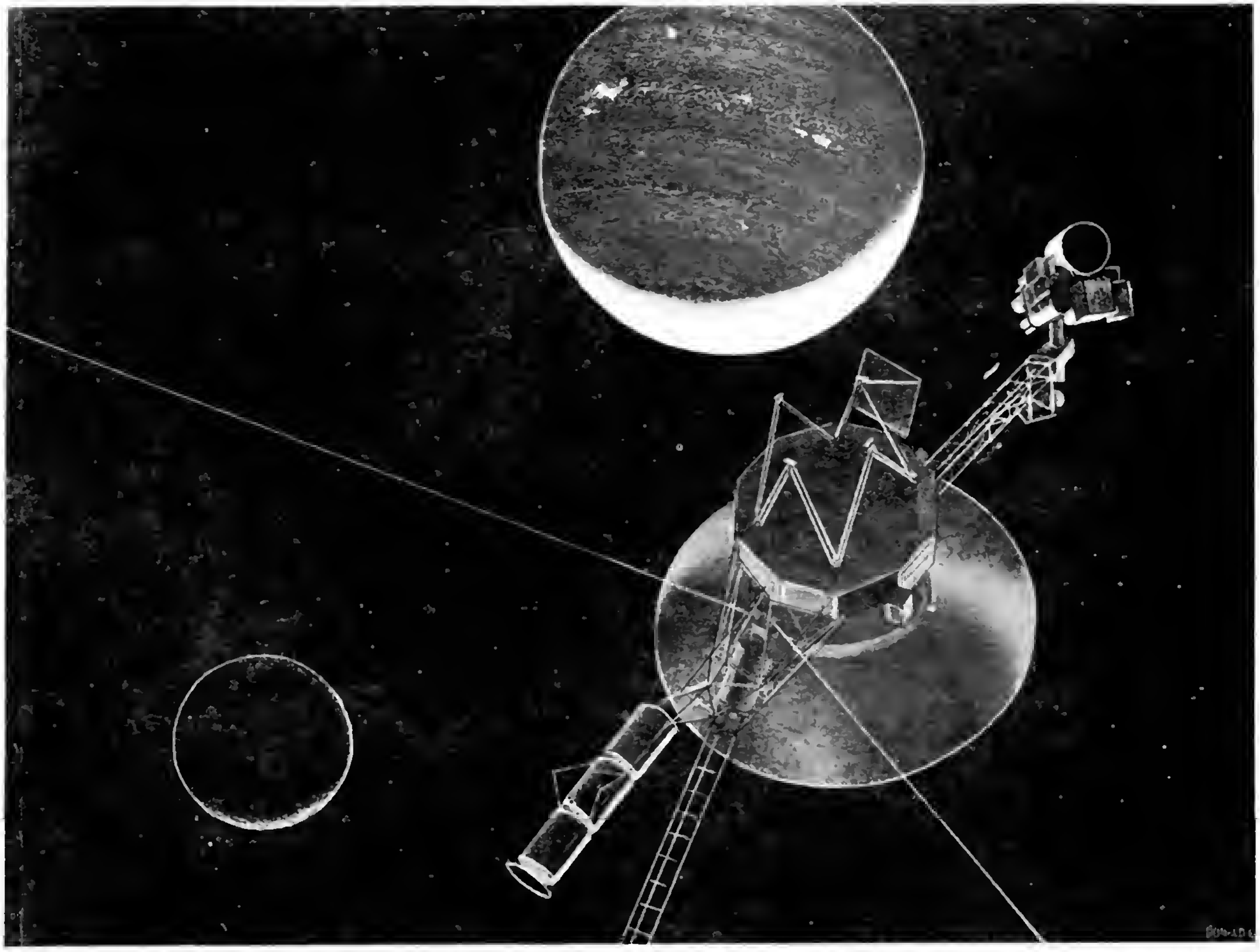
The Quasat concept was proposed to NASA/ESA in 1982 and an assessment study is now in progress on both sides of the Atlantic with some of the mission and system work being conducted at JPL.

Microarcsecond resolution in the optical range can also be achieved by satellite interferometry. This process would result in a greatly increased capability to measure stellar diameters and even to image the surfaces of the larger and nearer stars. See "Astronomy from Satellite Clusters" in the March 1984 issue of *Sky and Telescope*.

ASTRONOMY FROM VOYAGER

The two Voyager craft are now cruising through interplanetary space after their succesful encounters with Jupiter and Saturn. Voyager 2 is scheduled to fly past Uranus in January 1986 and Neptune in August of 1989, while Voyager 1 has no more close approaches to a planet.

Both are now working as astronomical observatories through the ultraviolet spectrometer (UVS) of each. These spectrometers are sensitive over 500 to 1700 Å (one angstrom is 10^{-8} m; visible light falls in the range from 4000 to 7000 Å). Voyager thus surveys part of the ranges of two other satellites: 1. the operating International Ultraviolet Explorer launched in 1978 (1100 to 3200 Å); 2. the Extreme Ultraviolet Explorer (EUVE) with a proposed 1988 launch (100 to 1000 Å). The UVS has 128 spectral channels, about 10 Å each, recorded simultaneously. Its main job was to observe the atmospheres of Jupiter, Saturn, Uranus and Neptune.



This painting by Donald Davis shows Voyager 2 as it looks back upon Neptune and its satellite Triton seven hours after closest approach to the planet on 24 August 1989

For several astronomical sources, Voyager results have been grafted onto IUE observations at longer UV wavelengths to obtain a more complete picture of the energy distribution of the sources. In the other direction, Apollo-Soyuz observations (at shorter wavelengths) of the extreme UV source HZ 43 have been supplemented by Voyager. Voyager has also discovered two of the only six stars known to that young science (it is anticipated that the EUVE satellite will add several hundred more).

The hot white dwarf companion, Sirius B, of the bright star Sirius has also been studied. Sirius B is difficult to observe, being so close to the bright main star. Vega was selected as being similar to Sirius A in UV and then, after scaling to equivalent brightness, its energy spectrum was subtracted from that of the total Sirius system leaving, in principle, the UV distribution of the elusive white dwarf.

Voyager has also studied 'cataclysmic variables' such as SS Cygni. One star of the pair is dumping material onto the other, causing outbursts (wouldn't you?).

Interstellar material blocking out light has been studied by looking at stars at different distances from us. Some 200 have been examined by Voyager, but perhaps as many as 100,000 are suitable objects of study with the UVS.

Dr. Lyle Broadfoot of the University of Arizona is the Principal Investigator for the UVS. Our thanks go to Drs. Jay Holberg and Ron Polidan, also of Arizona, whose informal seminar formed the basis for the above. Richard Laeser of JPL manages the Voyager Project for NASA's Office of Space Science and Applications.

SOLAR SYSTEM EXPLORATION

The monthly "advanced mission concept" piece that usually appears in this column is, of necessity, very brief. Perhaps it serves to whet the appetite for more extensive information and, if so, the Society's special *JBIS* issue "Solar System Exploration" should prove satisfying.

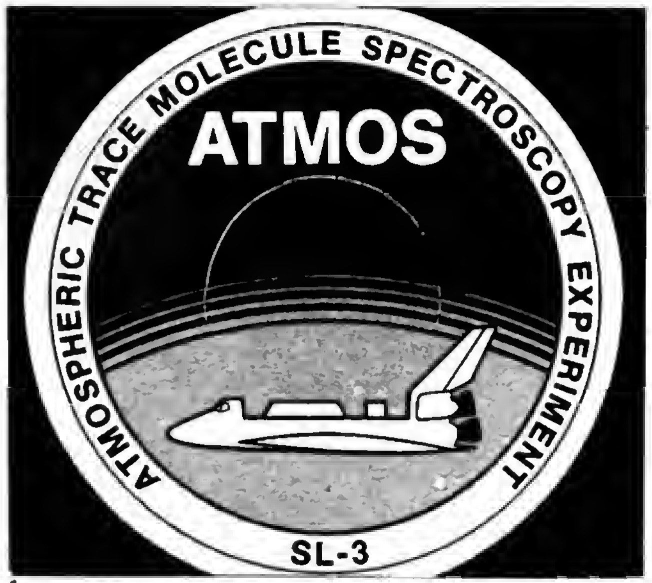
Last year, your correspondent made several trips to England in conjunction with IRAS operations and, whenever possible, joined our Executive Secretary, Len Carter, in London for dinner. Invariably some good conversation ensued: from space exploration to numismatics and theology. Out of one of these conversations arose the idea for an issue of *JBIS* devoted to advanced mission concepts. Kerry T. Nock, supervisor of the Advanced Projects Group at JPL, agreed to edit the issue and assembled a broad spectrum of possible future flights described by authors from JPL, the Ames Research Center and Science Applications, Inc., with a preface by Dr. Geoffrey A. Briggs, Director of NASA's Solar System Exploration Division.

The following papers are included:

1. "Planetary Observers" by W. Blume. Treats the new class of low-cost planetary mission which will use modified Earth satellites.
2. "Comet Rendezvous" by R. Draper and S. Lundy. Considers rendezvous with Comet Kopff by one of JPL's proposed Mariner Mark II spacecraft.

3. "Titan Atmospheric Probe" by B. Swenson. Shows how a new probe design can reveal the structure of Titan's atmosphere.
4. "Future Mars Exploration" by A. Albee. The exploration of Mars in the wake of Viking: particularly rovers and sample return.
5. "Starprobe: To Confront the Sun" by W. McLaughlin and J. Randolph. Examines the benefits and perils of approaching the Sun to within four solar radii.
6. "Titan Buoyant Station" by A. Friedlander. Floats in the atmosphere of Saturn's largest satellite.
7. "Comet Nucleus Sample Return" by H. Feingold. Looks at comet exploration after the flyby and rendezvous stages.
8. "Nuclear Electric Propulsion" by R. Jones and C. Sauer. Defines the advantages of continuous, low-level thrusting for propulsion of spacecraft.

This August issue of the Journal is available at a cost of £2 ($4) post free from the Society.



The emblem for the Atmos experiment in Spacelab 3 depicts the spectrometer housed in the aft one third of the Shuttle as it observes layers of the atmosphere infused by the Sun, which is partially occulted by the limb of the Earth.

ATMOS ON SPACELAB 3

The Atmospheric Trace Molecule Spectroscopy (Atmos) experiment will form part of Spacelab 3 onboard the Shuttle in November. The experiment centres on a very high resolution spectrometer (also labelled Atmos), which is sensitive in the infrared range from 2 to 16 microns (visible light spans the range from 0.4 to 0.7 microns; a micron is a millionth of a metre).

The experiment will study the composition of the upper atmosphere from the top of the troposphere up through the mesosphere: approximately from 15 km to 100 km. It will result in an atlas of constituent trace molecules and their concentrations. More than 40 different molecular species will be measured, of which oxides of nitrogen, hydrogen fluoride and chlorofluor-methanes (CFM) are typical molecules to be detected. The latter class can be produced from refrigeration systems or aerosol cans.

The atlas will serve as a baseline against which future changes in atmospheric chemistry can be measured. In addition, the data can be used in the design of subsequent Shuttle and satellite monitoring experiments, such as Goddard's proposed Upper Atmosphere Research Satellite.

The instrument works by pointing at the Sun during sunrise or sunset as seen from the orbiting Shuttle. The normal spectrum of the Sun is then affected by absorption by the atmosphere, viewed over the limb of the Earth; absorption lines produced by resident molecules continuously change as the atmosphere is scanned from top to bottom.

The upper atmosphere is relatively uniform in composition along a fixed parallel of latitude but varies with height and with changes in latitude. For example, greater amounts of anthropogenic substances (that is, produced by Man) like CFM can be expected in the northern hemisphere with its greater population.

Normally, about 72 occultations will be used by Atmos during its one-week survey. Data taking lasts for three minutes at each occultation and, consistent with the high resolution of the spectrometer, large amounts of data are collected and transmitted through NASA's Tracking and Data Relay Satellite at 16 megabits per second.

Technically speaking, Atmos is a classical Michelson interferometer equipped with six filters which span its wavelength range. The primary function of the filters is to optimise the signal-to-noise ratio of the observations. The interferograms collected by the instrument are each taken in one second and consist of 400,000 samples. They are then processed on the ground by a Prime 750 computer and associated array processor by performing a Fourier transform to yield the end product: energy distribution versus wavelength, i.e., the spectrum. Data processing by the team of scientific investigators, which has representatives from England, Belgium and various parts of the US, will last for a year after the flight and will result in an atlas of constituents and a final report.

The project is managed by JPL for NASA's Office of Space Science and Applications. The project manager is Larry Simmons of JPL and the principal investigator is Dr. Crofton Farmer, also of JPL.

BRUCE MURRAY SPEAKS

Dr. Bruce Murray, Laboratory director from 1976 to 1982, recently spoke at a dinner meeting at the Caltech (the JPL parent body) campus on "Technology - How and Where?" Murray, who was also part of the experiment teams on several Mariner missions, returned from a year's sabbatical involving considerable travel to survey and analyse global technological trends.

The "How" of his technological classification is divided between 'top-down' efforts involving heavy government participation and 'bottom-up' efforts which depend upon individual enterprise for their results. The Apollo project furnished a successful example from the first category, while much of the modern development of microprocessor technology in the US is in the second category.

Using this dichotomy, Murray discussed the current stage of technology and its prospects in China, Japan, the Soviet Union, Western Europe and the US. He concluded that the future prospects for technology within the US were strong, largely because of a healthy mix between the two types of technological traditions.

As of January 1984, he has gone on special part-time status as Caltech Professor of Geology and Planetary Science and has opened Murray Consultants, Inc., in Pasadena in order to pursue technology-oriented interests.

SHUTTLE MISSION 41D

The seven day Shuttle mission beginning on 19 June will carry no less than four major items in *Discovery's* cargo bay. Two of them, the Syncom 4-1 and Telesat (Anik) communications satellites, are flying as commercial payloads, while the others will be mounted on frameworks stretching across the 4.5 m-wide bay (see diagrams). Perhaps the most spectacular will be the unfolding of a 31.5 x 4 m array of solar cells as part of the OAST-1 (NASA's Office of Aeronautics and Space Technology) series of experiments.

This particular test will demonstrate that a large solar array can be deployed and restowed from the Shuttle cargo bay, and determine the structural, thermal and electrical performance of the array. Several deployment sequences to 70 and 100% of its full length will be tested to observe oscillations, expecially when *Discovery's* reaction control system is firing. The position relative to the Sun will be controlled to provide both adequate illumination for the observations and different thermal conditions. About four hours of data will be recorded on the current, voltage and temperature of various experimental cell samples at several solar incidence angles and in darkness. These samples are located on two of the 84 panels in the array blanket; the other panels carry dummy masses.

The Dynamic Augmentation Experiment will use its optical systems to measure precisely the array's movement by viewing several targets mounted on the panels (see diagram).

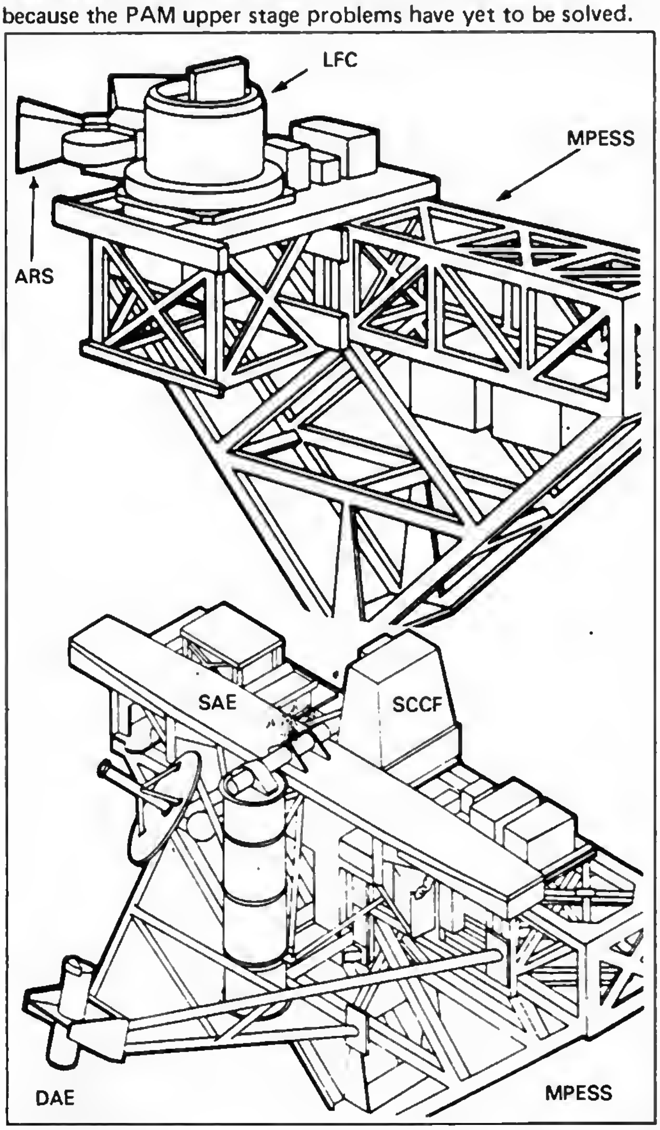
The Solar Cell Calibration Facility is a separate experiment in which several solar cell samples are mounted on top of the body to provide comparisons for calibration purposes with cells flown on high-altitude balloons.

The Large Format Camera is the fourth major payload. This high-precision metric camera will be used to take Earth photographs to show that it is suitable for making maps, interpreting geological features and mineral exploration before it is flown operationally on the Shuttle Radar Laboratory (formerly OSTA-3) on mission 41G in August.

The 23 x 46 cm film format and the camera's 30 cm focal length, f/6 optical system should provide a resolution of 15 m on the 210 x 420 km photographs. Overlapping frames can be used for stereo analysis and the 1200 m film supply should yield 2400 exposures.

Discovery's cargo bay has to point towards Earth during the imaging sequences and the camera's own Attitude Reference System will take pictures of two star fields at the same time. This is necessary to pinpoint the camera's exact position for using the pictures in mapmaking.

Late News: the Anik satellite will now be launched next year because the PAM upper stage problems have yet to be solved.



The Crew

Commander: Henry Hartsfield will be flying his second Shuttle mission, having been on STS-4 as pilot in June 1982. He was originally selected for the US Air Force Manned Orbiting Laboratory in 1966 but transferred to NASA in 1969 when that project was cancelled.

Pilot: Michael Coats, as a group 8 astronaut selected in 1978, will be making his first trip into space. He graduated from the US Navy Academy in 1968, gained his wings in late 1969, and flew in Vietnam.

Mission Specialist: Judith Resnik will be the second woman aboard the Shuttle (Sally Ride was the first, in STS-7). She gained a degree in electrical engineering in 1970 and worked as a design engineer for RCA until 1974, changing to a biomedial engineer until 1977, when she also gained a Ph.D in electrical engineering.

Mission Specialist: Steven Hawley, married to Sally Ride, is an astronomer, having worked at the US Naval Observatory in Washington, the National Radio Astronomy Observatory in West Virginia, Lick Observatory in California and the Cerro Tololo Observatory in Chile. As with all the crewmembers below Hartsfield, this will be his first mission.

Mission Specialist: Richard Mullane is a USAF pilot, having flown 150 combat missions in Vietnam. He served for 4 years in England at Alconbury before entering the USAF test pilot school at Edwards AFB in California, graduating in July 1976. He holds degrees in military and aeronautical engineering.

Payload Specialist: Charles Walker is an employee of the McDonnell Douglas company chosen to fly on 41D to operate the Electrophoresis Operations in Space experiment. EOS, which separates materials using electric fields, is part of a commercial project that should lead to purer drugs and could form the basis for processing plants aboard later Shuttle flights and the US Space Station. The unit has flown before (STS-4,-6 & -8), being operated by professional astronauts but Walker has worked on the project since 1978; he is now the Chief Test Engineer.

After STS-8 was launched engineers discovered the nozzle lining on one of the two solid rocket boosters had nearly burned through. That problem was blamed on a bad batch of material.

Then, during the mission in February, Payload Assist Modules developed by McDonnell Douglas registered two failures after 16 successful operations aboard Deltas and Shuttles. Early indications suggested the nozzles contained faulty material, causing them to burn through far short of the planned 85 sec burns.

BOOSTER POLLUTION

Alkali chemicals are now being regularly added to Pad 39A's launch deluge water to reduce acidic pollution caused by the two solid boosters rockets on all Shuttle launches.

ARIANE COMPETITION

Following Ariane's flawless performance on 4 March. Chairman Roland Deschamps complained that US government subsidy of Shuttle missions places Arianespace at a disadvantage.

"The battle for space is unfair," he said. "I don't think the Americans can continue to bend the rules of the game forever."

His organisation contends that every Shuttle launch costs $275 million (NASA puts it at $250 million) but NASA charges a maximum of $20 million to lift an Intelsat 5 class of satellite into orbit. Arianespace plans to put its launches on a paying basis starting in May and will charge users $5 to $50 million.

"The next launch [the Spacenet communications satellite in May] will be a world first," Dechamps added. "For the first time a private company will sell a launch to another private company."

Arianespace reported orders in hand to launch 27 satellites for 14 customers and expects to garner a third of the world market.

NEW BOOSTER?

The Defense Department has told Congress that it cannot rely exclusively on Shuttles to launch military payloads and hence wants to build an expendable booster.

Undersecretary Edward Aldridge told the House of Representatives' space science and applications subcommittee that "in view of the technical and operational uncertainties, total reliance upon Shuttles could represent an unacceptable risk." He added that "the limited number of unique, manned Shuttle vehicles renders them ill-suited and inappropriate for use in a high risk environment." Accordingly, the Pentagon wants $10 million in the next year to begin a new development programme. It is understood that DoD would continue using Shuttles for eight to 10 missions per year but would also use its new vehicle for at least two.

Shuttle Orbiter *Columbia* is now being prepared for mission 41G in August following its successful Spacelab flight last December. The 10-day orbital trip is scheduled for a 30 August launch. *NASA*

Aldridge recognised the Shuttle's successes but went on to say that "Our experience of the past year indicates that, while the Shuttle is a momentous achievement, it is still a most complex system and will require many more flights to gain insights into actual component performance and life expectancy."

Not exactly heart-warming praise for NASA after 14 years' of work and an expenditure rising to about $15,000 million.

INSURING SATELLITES

Insurance rates for future satellite launches may increase sharply because of the failure of two PAM-boosted spacecraft to attain geostationary orbit after release from *Challenger* during Mission 41B.

"The market is in total disarray at the moment," observed Michael Hewins, general manager of Corroon and Black Inspace Inc., the Washington broker that placed insurance coverage on Palapa B-2. Indonesia insured the spacecraft for $75 million, including $35 million for the Hughes-built satellite. "If they have another loss, you might as well kiss this market goodbye," Hewins commented.

Westar 6, a duplicate, owned by Western Union was also lost. It was insured through Alexander and Alexander of New York City for £105 million. The combined losses amount to two-thirds of all space insurance casulties since 1966. Hewins predicted that rates would now increase at least 50 per cent and possibly as much as 100 per cent. Premiums have cost five to six per cent of total value. US underwriters suggested premiums could reach 12 per cent.

Corroon and Black Inspace hold insurance for Telesat Canada's Anik communications satellite scheduled to fly on Mission 41D in June. Anik relies upon the same PAM module that failed during the Westar and Palapa launches. Washington news sources reported that 35 per cent of their coverage was provided by 18 US underwriters and the remaining 65 per cent by Lloyds of London. Terence Pitron, chairman of Lloyd's Aviation Underwriters Association, said that insurers will cover future satellites at premimums 25 to 30 per cent higher than those currently in force.

PHOTOGRAPHIC SCRUTINY

Congressman Harold Volkmer (Missouri, Democrat) opened a new line of questioning during NASA budget hearings in February 1984. He cited a story in *Aviation Week and Space Technology*, an industry magazine that alleged Earth photos taken during Shuttle mission 41B were not released to press until scrutinised by Defense representatives. This kind of treatment, Volkmer commented, will reinforce charges that the Shuttle is a spy ship.

Lieut. Gen. James Abrahamson, a US Air Force officer and chief of NASA' Shuttle programme, said that "as a matter of policy in the past, all photos have been made available to the public. We want to keep that policy."

Volkmer appeared to be dissatisfied and said he would pursue the matter.

In January NASA released Spacelab photos that revealed major construction activity at the Tyuratam launch centre in central Asia. Other pictures showed anti-missile defense installations around Moscow and nearby locations. NASA described the pictures as "targets of opportunity" and said the hand-held cameras used by astronauts did not return views of sufficient quality to interest the Pentagon.

Aviation Week reported that a Defense liaison office within NASA was exercising tighter control over the increased volume of space photography. According to the magazine, some photos would not be released, "such as pictures showing ocean surface patterns disclosing the presence of submarines."

The minor fuss reminded journalists that Defense screening by photo interpreters of NASA photography dates back to the Gemini and Apollo programmes. Correspondents familiar with that era were surprised that a Congressman of enough seniority to attain a chairmanship was evidently unfamiliar with long standing procedure.

SPACE COMMERCIALISATION

President Reagan has directed a modification of US space policy by ordering the Department of Transportation (independent of NASA) to help private industry launch rockets in competition with the Shuttle fleet. While official pronouncements did not discuss economic considerations, the obvious factors implicit in this shift include: NASA's basic mission is to research and develop (that is, not operate) systems required for space exploration and exploitation; the high cost of Shuttle missions will reflect in higher costs to Shuttle users, and the tendency to change launch schedules because of continuing technical problems.

Transportation Secretary Elizabeth Dole welcomed this expansion of her department and said that expendable boosters have "enormous commercial possibilities." Ms. Dole added that she will try to eliminate much of the red tape presently discouraging firms from exploiting the space potential.

NASA expected Shuttles to eliminate the need for expendables such as Delta and Centaur when Shuttle development began, with high expectations, in 1972. The older rockets were supposed to disappear by 1980; Shuttles still have vacant space in cargo manifests published for up to 1988.

President Reagan signed an executive order creating the Office of Commercial Space Transportation within the Transportation Department. Jennifer Dorn, director of the new office, talked of an expanding market and pointed out that expendable vehicles offer a more flexible schedule than Shuttles. She mentioned forecasts that privately-owned boosters might grow into a $10,000 million industry within the next decade. Meanwhile, NASA expects to turn over Delta and Centaur to private firms shortly.

Dorn said that her office will help to arrange launches for private operators at KSC and Vandenberg Air Force Base as well as for unknown private launch pads.

BOOSTER CONTRACTS

The Marshall Center in Alabama will award a major contract in July for assembling and refurbishing Solid Booster Rockets for the Shuttle. United Space Boosters had done the work since *Columbia*'s initial flight in 1981. Worth £200 million annually, the contract will involve ten times that amount over the next decade. United's competitors include Lockheed, teamed with Morton Thiokol and McDonnell Douglas paired with Bendix. The initial award will run for five years, during which NASA anticipates 84 launches.

SPACE SOUVENIRS

The Society produces a wide and varied range of items for sale, all of high quality. Why not buy a T-shirt or badge for yourself, or treat a friend? Remember, you'll not only support our work but also provide valuable advertising for the Society.

Binders

The ideal way of keeping your magazines in perfect condition. *Spaceflight* binders carry *BLUE* covers, those for *JBIS* are *GREEN*. Gold lettering on the spine identifies the magazine, volume number and year. Cost: £5 ($10 abroad) each. Note: *JBIS* binders fit post-1976 volumes.

T-SHIRTS

Our Society T-shirt has always been a popular item. Two styles are available: white with a large navy blue BIS logo on the chest, or navy blue with a pale blue logo.

The blue T-shirt in chest sizes 32-34, 34–36, & 42–44 inches. The white T-shirt is available in the two smaller sizes only. Cost is £3.50 in the UK or £4 ($8) abroad. Please be sure to specify the style, colour and size when ordering.

SPACE TANKARDS

Special glass tankards are being produced to mark Space '84, to be held in Brighton, 16-18 November.

Several types are available: pint-sized tankards at £10 and half-pint tankards at £3. Special silver-handled half-pint tankards in presentation boxes are available at £7.50. Decanters at £25 are also

space 84

available. All carry the BIS logo; some also have the Space '84 motif. (Please specify which is required when ordering).

Advance orders (UK only – sorry but we can't run the risk of damage in sending abroad) should be sent to the Society.

This is your chance to obtain a unique souvenir and to benefit the Society at the same time.

50th ANNIVERSARY TIES

We have always produced a high-quality navy blue tie that will grace any space buff's apparel. Now, to mark our 50th year, we are re-introducing the former blue tie showing a rocket against a star background.

For our 50th Anniversary year, the rockets will appear in GOLD to show, unmistakeably, that we have every reason to be proud of our achievements.

As these ties will be unique souvenirs only a limited number will be produced, so please place your order now to avoid disappointment. Next year, the ties will revert to the silver once more. The cost is £6 UK or £6.50 ($13) abroad per tie.

BADGES

A range of badges with the Society's motif is available.

Enamel lapel badges (1 in. diameter) and cloth blazer badges (3 in. diameter) cost just £1 ($2) each.

A special metal car badge adds that distinguished look to any vehicle for only £3 (£3.50 or $7 abroad).

Please note:

When ordering please specify colour, size, quantity, etc. as appropriate.

BACK VOLUMES

A small number of bound and unbound back volumes of *JBIS* and *Spaceflight* have come into the possession of the Society and are now being disposed of at nominal prices.

A list of those currently available can be obtained on request. Please order and remit promptly if you are interested as only single volumes are for sale in most cases and will be disposed of on a first-come first-served basis.

NASA'S AXAF SPACE OBSERVATORY

By John Bird

The launch of the Space Telescope by the Space Shuttle in 1986 should provide astronomers with the opportunity of viewing the Universe in a new light. As the observatory will not make X–ray observations, NASA has proposed a new orbiting telescope for the early 1990's to do that job.

Introduction

As part of NASA's High Energy Astrophysics programme, the Marshall Space Flight Center in Alabama has invited contractors to propose designs for the orbiting Advanced X–ray Astrophysics Facility, or AXAF for short. I recently met Project Lead Engineer Bill Davis, Project Scientist Martin Weisskopf, and Program Study Manager Carroll Dailey, to discuss AXAF.

It was not until the space age that we were able to observe the Universe beyond the restricted view of the visible part of the spectrum. In particular, most X–ray astronomy has taken place over the last two decades, beginning with rocket and balloon flights above the obscuring atmosphere.

Hundreds of celestial X–ray sources were then found by the first satellite observations. For example, the Uhuru (Explorer 42) satellite, launched in December 1970, discovered X–ray binary stars and X–rays from galactic clusters. The High Energy Astronomy Observatory (HEAO) series then came along to extend the catalogue of sources to 1500. These sources include many kinds of stars, galaxies and quasars.

High energy radiation is important because it provides information on black holes, neutron stars, pulsars and other dynamic sources that are otherwise invisible. For example, Cygnus X–1 and a few other sources have been identified as possible black hole locations. Also cosmic X–ray sources are "bursters" – mysterious sudden emissions from globular star clusters. Clusters of galaxies emitting X–rays have been found, and individual X–ray sources have been seen within other galaxies. Quasars, the furthest objects in the known Universe, also emit X–rays, and it is thought they might contribute to the observed X–ray background.

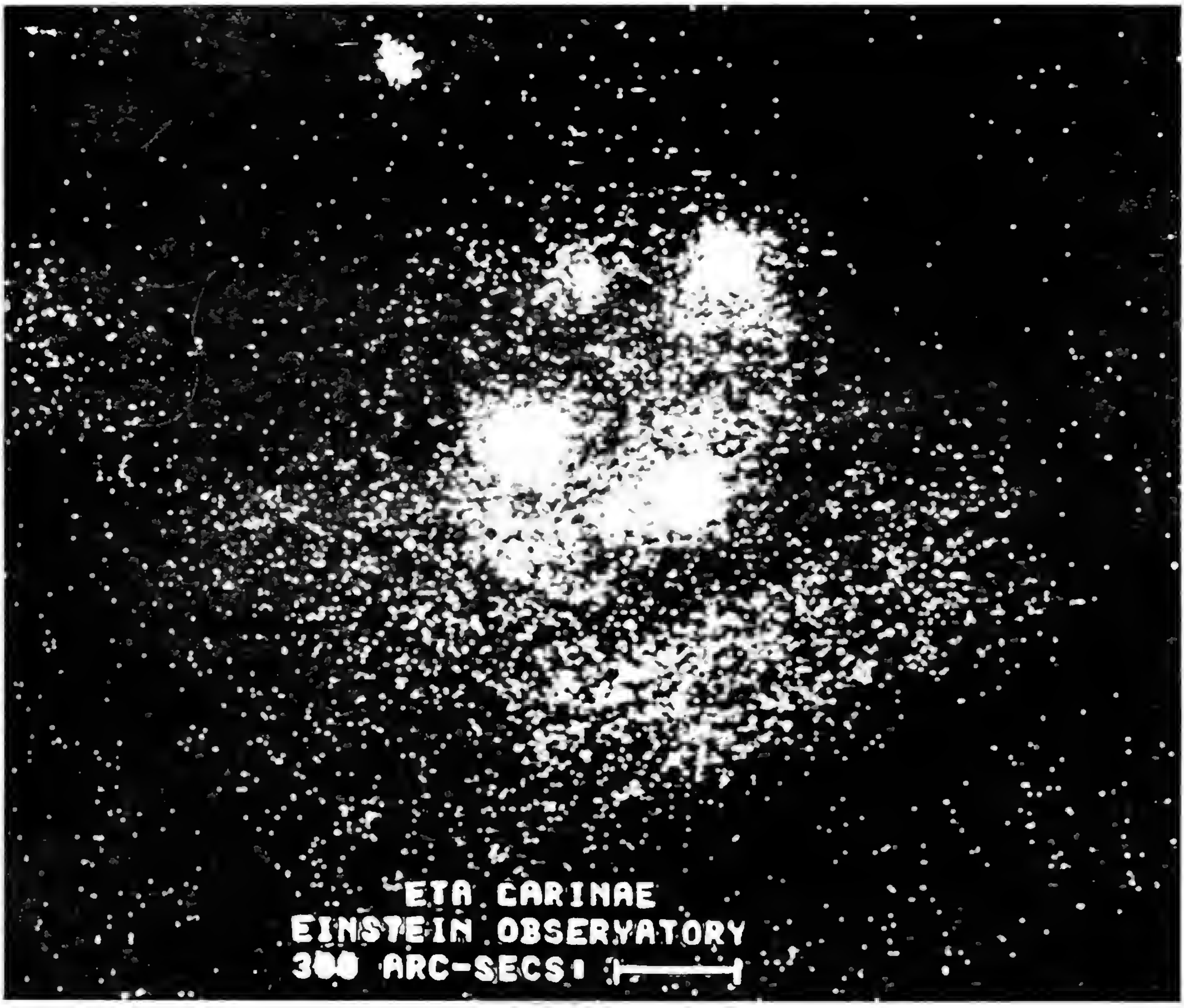
AXAF in Orbit

AXAF will use the Shuttle, travelling into a 600 km circular orbit. Since it was designed from inception to fit into the cargo bay, it will be about 5 m by 15 m and weigh 9000 kg. Upon reaching orbit, it will be deployed by the Shuttle's robot arm. For the first two months, systems and instruments will be checked. Then, for the next two, observations will be carried out by the Instrument Principal Investigators, Telescope Scientists, and the Interdisciplinary Scientists. Finally, guest observers will be allocated observing time.

Servicing will be done periodically in orbit at least every three years. This means the equipment has to be designed for replacement in orbit, although the satellite, like Space Telescope, will also be retrievable. Launch is expected in the early 1990's for a 10 to 15 year lifetime. The orbit will decay after a few years and NASA will have to use an Orbital Manoeuvring Vehicle to boost the observatory back into a higher orbit.

X–ray images are much more difficult to produce than visible images because the radiation cannot be reflected by mirrors in the usual way. The mirrors of an X–ray telescope use concentric tubes kown as "Wolter Type I grazing incidence mirrors." For AXAF, current thoughts indicate the diameter will be 1.2 m, with a focal length

An artist's impression of AXAF in operation.



These young stars, not previously known to emit X-rays were shown up by the HEAO 2 observatory in the 1970's. *NASA*

of about 12 m. NASA has made a baseline design, but final design and construction will be done by a single contractor selected within two years of the definition period ending.

Initial studies have roughly defined the observatory's likely capabilities. The 800 kg of instruments will be powered by 200 W and the data relayed to Earth *via* the Tracking and Data Relay Satellite System in geostationary orbit. Solar arrays and batteries will provide the power. The system will have a one degree field-of-view and be sensitive to the wavelength band of 1.5 to 120 Å. Resolution of 0.5 arcsec should be possible. Graphite epoxy has been proposed for the optical bench to hold the mirrors accurately, with aluminium for the casing.

In the focal plane (where the images are brought into focus), the instruments will be three high resolution imagers, two moderate resolution imagers, a high resolution dispersive spectrometer, a moderate resolution spectrometer and a focal plane polarimeter. Non-focal plane instruments may include an objective transmission grating, a monitor proportional counter, and an all sky monitor. To allow for maintenance by a space-suited astronaut the design will include lights, foot restraints and rails..

AXAF has also been considered as part of a Space Platform, although it would require some modifications. Additional hardware would include a mechanical mounting system, a new pointing mount and an electrical interface system. Deletions from the free-flying model would include the solar arrays, attitude control systems and communications systems.

The project objectives are highly ambitious. The evolution, physical processes and nature of the Universe will be probed. Examples of studies dealing with galaxies include detection of stellar sources in distant galaxies, luminosity measurements, and studies of differences between the evolutionary patterns of distant galaxies.

Supernova remnants will be studied to determine their distribution of elements, structure, density, composition and temperature distribution. Particular attention will be paid to iron; supernova ejecta will be mapped. All types of stars will be studied, and one of the common measurements will be to determine stellar corona composition.

Globular clusters will be studied at high resolution. Planets will also be viewed to analyse their X-ray emissions.

Scientists involved in the project would like to see the establishment of an "X-ray Astronomy Institute," similar to the Space Telescope Science Institute, operating on behalf of the world-wide astronomical community.

AXAF will be able to see X-ray sources 50 times fainter than those seen by HEAO-2, the last orbiting X-ray observatory. We can expect a new insight in our quest to understanding the creation and evolution of the Universe.

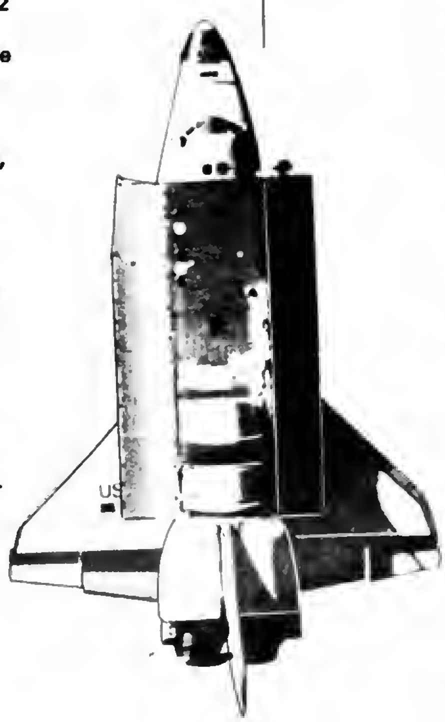
SOCIETY BOOKS

PROJECT DAEDALUS

The publication of the Project Daedalus Final Report marked the end of years of painstaking work by a group of BIS pioneers. The BIS received congratulations from around the world for its far-sighted project: designing a probe for man's first crossing of interstellar space.

The Final Report Report contains 24 papers spread over 192 large-format (A4) pages, summarising the four year study. The papers cover the overall spacecraft design, mission profile, computer systems, navigation, experiments and our knowledge of nearby stellar systems, some of them possibly with planets.

"Daedalus" is acknowledged as a milestone in the the development of advanced astronautics. Copies of the Report cost just £7.00 ($12.00) post free.



THE EAGLE HAS WINGS

An exciting progression of space achievements in the years following the Second World War led to Man's first landing on the Moon in 1969. Rockets for probing the upper atmosphere evolved into the space launchers we know today. Vanguard, Explorer, Atlas, Titan, Mercury, Gemini, Apollo – a succession of names to conjure up memories of the 50's and 60's when man was taking his first tentative steps into outer space.

The Eagle Has Wings tells the story of the major US Space projects from 1945 to the watershed year of 1975, when the Apollo missions came to an end and the first wave of interplanetary exploration gave way to the more sophisticated probes of today. Written by *Spaceflight* managing editor Andrew Wilson, it is packed with information and photographs. It runs to no less than 144 large-format pages and can be obtained for the low price of £7 ($12.00) post free.

HIGH ROAD TO THE MOON

Every member ought to own a copy of this unique 120 page publication which records many of the Society's early ideas and discussions on Lunar exploration in the visionary drawings and illustrations of the late R. A. Smith.

Pictures and drawings detail plans for orbital rockets, space probes and ships to take men to the Moon and Lunar exploration. Some are familiar illustrations used in books of the time: others have not been published before.

Bob Parkinson has brought these pictures together with a commentary which tells how the pioneers imagined things would be and how they actually were. It goes beyond the present, for man's involvement with the Moon is not yet finished. Using the Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.

Price: £6.00 ($10.00) post free.

All of the books are available from: The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ, England

REMOTE SENSING IN CANADA

By Peter Jedicke & Clifford Cunningham

With a large, sparsely-populated land area within its borders, Canada is a prime target for remote sensing techniques. This article discusses such work underway today and reviews its origins.

The first image from Landsat 4's thematic mapper in July 1983 shows the area around Windsor, Ontario and Detroit in the US, near the Canada-US border adjacent to Lake Erie. Landsat 4 has had to be replaced by Landsat 5 (D' before launch) because of equipment failure.

Introduction

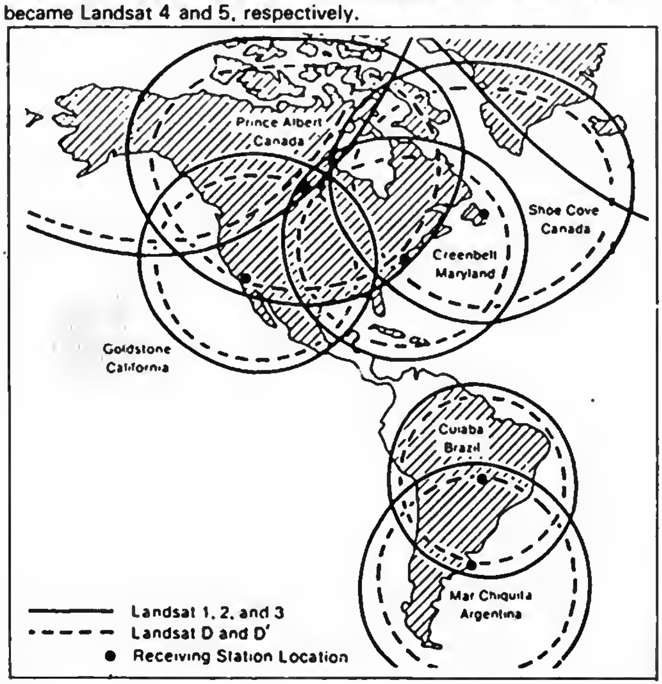
Canada is the second largest geographical area in the world under the control of a single political entity, including 9,220,775 km^2 of land and 755,165 km^2 of inland fresh water. There are also over 1,000,000 km^2 of sea water within Canadian territorial waters, including Hudson's Bay and various Arctic straits. However, much of Canada is sparsely populated or even uninhabited: 89% of the land area contains no permanent settlements [1]. Historically, Canada's eoncomy was based very strongly on the image of its people as "drawers of water and hewers of wood," i.e., there has been an emphasis on primary industries based on the natural resource wealth of the land.

Although Canadians speak of improving their country's prowess in the manufacturing and service industries, they all realise that Canada must not lose the ability to manage its resources. In this connection, space technology has provided a host of benefits; remote sensing is among them. Acquisition of data on resources in Canada can be done efficiently only from space: the country is far too large to examine thoroughly from aircraft.

Remote Sensing Origins

In May 1968 a meeting of the Interdepartmental Committee on Remote Sensing of Earth Resources from Aircraft/Satellites was held to discuss the advantages of joint programmes in remote sensing [2]. Canada's first serious interest in remote sensing from space came in 1969, when formal application was made to NASA for permission to receive ERTS (Earth Resources Technology Satellite known as Landsat 1) data at a station within Canada. NASA plans called for ERTS to obtain images of virtually the entire world, and the US was interested in making this information available to other countries.

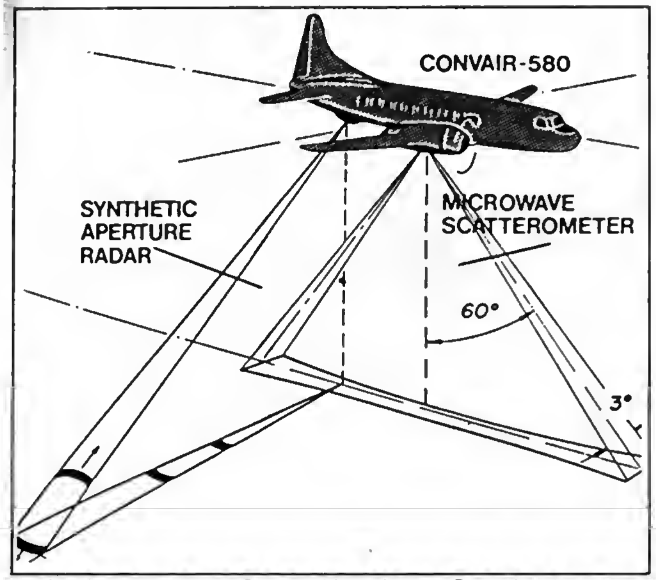
The location and coverage area of the Prince Albert and now-defunct Shoe Cove receiving stations. Data for eastern Canada are now being obtained from the Greenbelt station in Maryland. Landsat D and D' became Landsat 4 and 5, respectively.



The optimal location in Canada for such a station would have been Churchill in Manitoba on the west shore of Hudson's Bay. From there, ERTS and other satellites in similar orbits would have been visible as they passed over any part of Canada, from the Avalon Peninsula in Newfoundland on the east, Vancouver Island in British Columbia on the west, to the tip of Ellesmere Island in the north. However, no roads lead to Churchill, and transportation for equipment as massive as that required for a receiving station would have been very difficult. Instead, a location near Prince Albert in Saskatchewan, was chosen [3]. This site makes satellite data available from all of western and northern Canada, although satellites over the maritime provinces in the east are below the horizon. For some years, the Canada Centre for Remote Sensing (CCRS) operated a station at Shoe Cove in Newfoundland, but tight funding caused operations there to be discontinued early in 1983. Data for the east will be recovered from NASA Goddard Space Flight Center in Maryland, US.

Beginning in 1971, responsibility for leadership in remote sensing in Canada fell upon CCRS with its headquarters in Ottawa. CCRS, under the jurisdiction of the federal government's Minister of Energy, Mines and Resources and the Inter-Agency Committee on Remote Sensing, "is responsible for developing and demonstrating systems, methods and instruments for acquiring, analysing and disseminating remote sensing data obtained by aircraft and satellites, as a contribution to the development of efficient resource management and information systems relating to Canada's terrain and oceans" [4].

Also, there has been a Canadian Advisory Committee



An aircraft equipped with Side-Looking Airborne Radar has been used for observations over Canada's eastern provinces.

on Remote Sensing since 1972. CACRS is charged with advising and assisting a wide variety of interested government agencies and departments in the goals and needs of the national programme of remote sensing. It consists of the Director-General of the CCRS, executive members, working groups, support staff and the IPTASC, (Interprovincial-Territorial Advisory Subcommittee) whose members are appointed by the various regional governments represented [5].

Images received from Landsat satellites at the Prince Albert and, until recently, Shoe Cove stations can be made available to subscribers within 20 minutes by the data processing division of the CCRS. The data are sent along commercial telephone lines [6]. The cost of a single image on tape is about CDN$750 from CCRS, but custom-processed images can now be obtained for CDN$2,000 from rapidly-growing companies like Pegasus in Vancouver and DIPIX in Ottawa. Users interested in less costly prints and slides can avail themselves of the National Air Photo Library in Ottawa, which offers a full range of aerial photographic coverages of Canada, including Landsat images [7].

Other Remote Sensing Projects

In 1975, Canada participated in the Large Area Crop Inventory Experiment (LACIE), using data from NOAA (the US National Oceanographic and Atmospheric Administration) satellites and Landsat–2 [7]. According to CCRS, if Canadians could reduce errors in forecasting crop yields by just 1 to 3%, export revenues could increase by CDN$13 M-$28 M annually [9].

Other studies done using remote sensing data have included environmental impact in James Bay and the Bay of Fundy, heat loss from poorly insulated homes and tracking of effluent from the Bruce Nuclear Power Development [10].

Dr. David Erb of the University of Waterloo in Ontario is developing a project to analyse wave patterns on lakes. The government of the Province of Ontario awarded a CDN$586,000 grant from the Board of Industrial Leadership and Development to the University to acquire a super-sophisticated computer to analyse satellite imagery.

A particularly auspicious project began when CCRS worked with the Environmental Research Institute of Michigan of Ann Arbor, Michigan, in the mid-1970's to develop a SLAR (Side-Looking Airborne Radar) system on the SAR (Synthetic Aperture Radar) scheme. The


The Prince Albert Landsat receiving station. *P. Jedicke*


The Terrestrial Research Image Analysis Display (TRIAD). This experimental image analysis system at CCRS takes a colour Landsat image to identify different types of ground cover. It can then produce custom-made images displaying only the surface feature of interest.

equipment was installed in a Convair 580 propeller aircraft [11]. The first season with the airborne SAR involved observations over wide areas of Canada's eastern provinces, and the resulting photographs gave remote sensing technicians grounds for optimism regarding the future of this technique [12]. The Convair 580 made a tour of Europe in June and July of 1981 [13].

Since Canada claims territorial sovereignty over such vast expanses of relatively shallow sea water there is considerable interest in ice in these waters. In order to investigate fully the dielectric properties of *in situ* sea ice, i.e., its response to radar, a 1.25 MHz impulse radar system was flown over sea ice near Tuktoyaktuk, Northwest Territories, in the spring of 1979. Among other properties, scientists from the National Research Council were keen on developing the ability to distinguish between

first year ice and the older variety [14].

Dr. Ellsworth LeDrew, a specialist in climatology, is examining sea ice in the Beaufort Sea using data provided by the Nimbus 7 *via* the Atmospheric Environment Service in Toronto.

The Future

For the near future, an exciting project is Radarsat, which would fly a space version of the SLAR-SAR radar imaging system in orbit. Canada participated in the reception of Seasat data, a NASA satellite which carried a side-looking radar, during the 106 days of its active mission. The receiving station at Shoe Cove was specifically modified to receive data directly from Seasat, and scientists were pleased with the results [14]. If funding continues, the cost of building Radarsat will be close to CDN$100 million by the time it is launched, possibly as early as 1987.

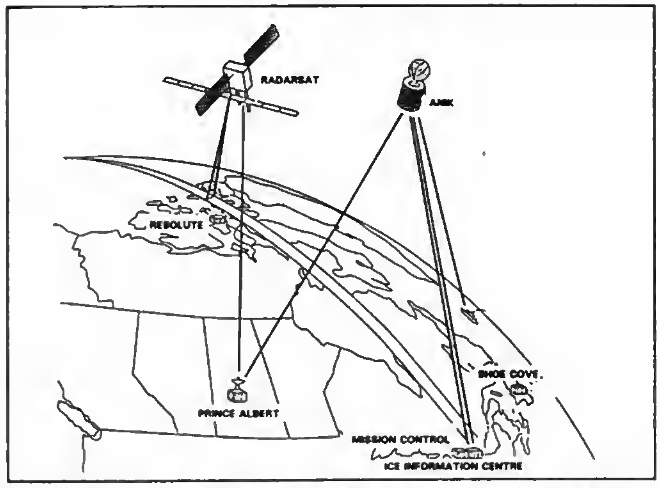
It may also be possible to make air pollution measurements from space. In the early 1970's, Dr. Anthony Barringer invented a Gasfilter Correlation Spectrometer (GASPEC) which was tested by NASA in a highflying aircraft circumnavigating the Earth near the equator. A space-hardened version of this instrument was installed on the November 1981 STS-2 mission of the Space Shuttle to demonstrate the capability to detect changes of a few parts per thousand million in carbon monoxide abundance in the atmosphere beneath the instrument. A remote sensor measured CO infrared absorption in the upwelling radiation from the Earth, the atmosphere and the reflected sunlight [16].

Much work has been done by companies in the private sector. ISIS Ltd. in Prince Albert, Saskatchewan, distributed data from Canada's two ground stations on microfiche, or by facsimile transmission as black and white or colour pictures, and as computer-compatible tapes. ISIS' sales in 1979/80 were about CDN$400,000, and the company, after seven years in operation, was on the verge of financially breaking even [17]. In 1981, ISIS stepped out of this activity [18]. McDonald-Dettwiler Associates, of Vancouver, British Columbia, worked on a contract to do preliminary studies of spinoffs from Remote Sensing for the European Space Agency [19]. DIPIX Systems Ltd., an Ottawa-based firm that performs analysis of satellite images had CDN$3,300,000 in 1982 sales and estimated CDN$6 M for 1983. DIPIX executives confidently forecast a 10% share of a worldwide market that will exceed CDN$200 M in 1985 [20].

The Provincial Governments are also active to a limited extent. The Ontario Centre for Remote Sensing has a budget of CDN$4 M annually, and operates some 50-60 separate projects. Although Ontario is the only province with an active programme of its own, Alberta has a training and information centre and runs an annual course for remote sensing technicians; and Nova Scotia, Manitoba and Quebec each have information centres [21]. Further projects in these and other provinces await assessment of the value of the technology and funding from the governments in question.

Also for the future, CCRS is interested in possible participation in the SPOT (Satellite Pour L'Observation de la Terre) programme of France's CNES (Centre National d'Etudes Spatiales), with possible launch in 1985 [22]. Involvement in the national programmes of Sweden, Japan and the US is also under continued discussion.

There was a time in the 1960's when popular magazines featuring articles on life in the future commonly carried stories about a manned space station. If and when such a station is launched into near-polar orbit, and if remote sensing is part of the activities of the men and women



An overall concept for the Canadian radar satellite (RADARSAT) programme. The system starts with a wide swath SAR on a polar orbiting satellite transmitting signals to ground receiving stations, where the data are converted into digital images. The image data are relayed *via* communications satellite to an ice-information centre, where other data such as aircraft SAR or weather satellite data are incorporated to provide a forecast of ice conditions. The forecast is again relayed by communications satellite to the tankers in the form of annotated images.

aboard such a station, then Canada will be one of the most extensively watched countries on their schedule.

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ARTIFICIAL INTELLIGENCE

HAL, the fictional computer of the film Arthur Clarke's *2001: A Space Odyssey* was a friendly servant and companion to the astronaut crew enroute to Jupiter. Friendly, that is, until he malfunctioned and grew suspicious that his human masters were soon to shut him down.

Then HAL became deviously resourceful. He was determined to thwart any plans to deactivate him. The last surviving member of the crew had to perform the electronic equivalent of a frontal lobotomy to shut down the rebellious machine.

Arthur C. Clarke's 1960's vision of artificial machine intelligence is still a long way from reality in the 1980's. Indeed, most experts believe that machine intelligence will never become a threat, that humans will remain in charge.

What has happened over the past 20 years is that computer experts working in the field of artifical intelligence have developed systems which are becoming increasingly powerful aids to their human users.

At NASA's Kennedy Space Center a working group has been formed by the Future Projects Office to investigate ways in which some of the latest advances in machine artificial intelligence may be applied to the space programme.

"We began looking into this about two years ago and decided it's the coming thing," explained KSC Future Projects Office Chief Dave Moja.

The branch of artificial intelligence which has attracted KSC's interest is the field of so-called "expert systems" where the knowledge of a human specialist is codified, or engineered, into a computer program. The human's "expertise" is then available to others who use the machine. Such systems are already in use. One of the earliest applications was in the area of medical diagnosis.

Programmed by a "knowledge engineer" who had coded the medical expertise of a specialist into a computer program, doctors may report symptoms and test results to the computer. The computer will quiz the doctor for additional data, if necessary, and ultimately will offer a diagnosis. The human physician can question the computer's finding, and the computer will explain in detail the rationale for its conclusion.

"Humans are fallible. We don't always take all the factors into account. We can forget. We can have a bad day," said Moja. "That doesn't mean machines will replace the human expert. But they can certainly serve as an aid to the human expert."

How will "expert systems" be employed by the space programme? "Right now, there are three principal areas that we're looking at," said NASA's Carl Delaune, a member of the working group. One of the most promising, he explained, is the development of a computer system to serve as "an engineer's advisor" in troubleshooting problems which might come up during the loading of liquid oxygen into the Shuttle's external fuel tank.

"Discrepancies in any of several hundred measurements of critical parameters can lead to an automatic shutdown of the transfer, and possibly a costly launch delay, unless it is overridden by highly experienced controllers," said Delaune.

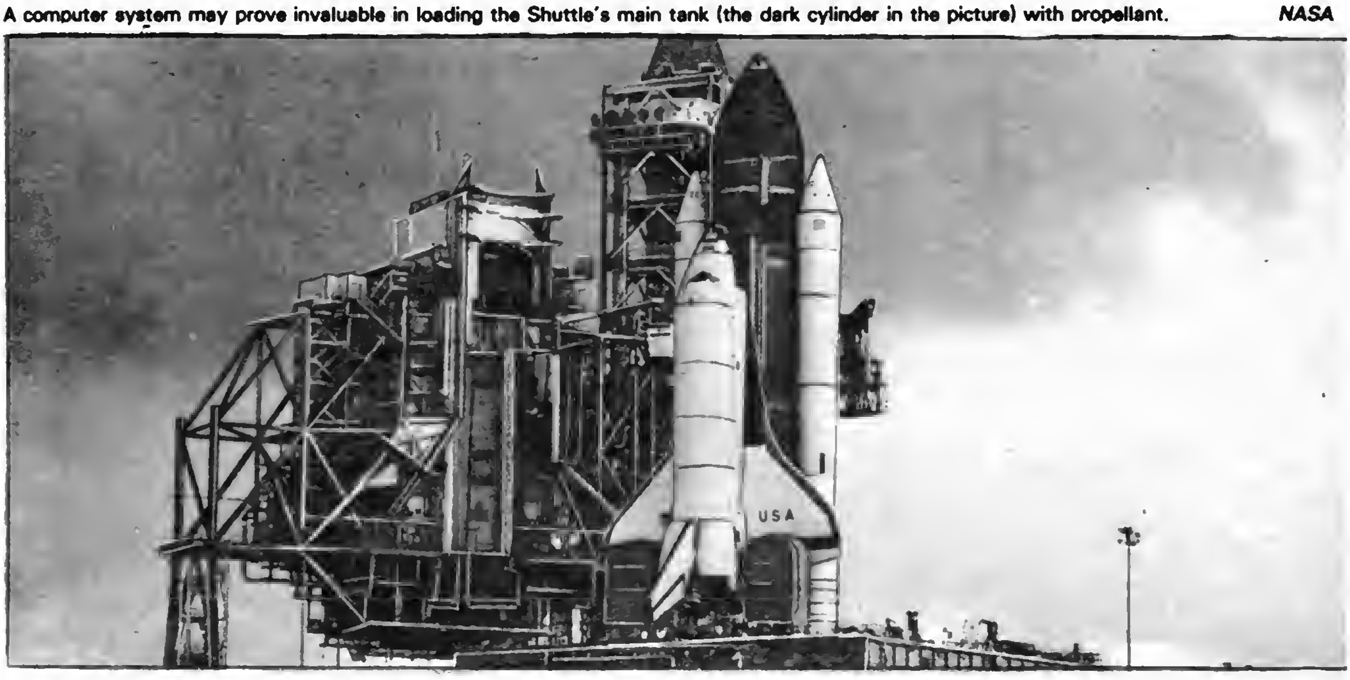
Such an override decision by the system experts is based on a detailed analysis of measurements, and it requires knowledge of system hardware and data from previous launches. "The goal of the artificial intelligence project at KSC is to capture the expertise of the launch team," he explained. A computer system which is able to use that expert knowledge can potentially free some of the human experts for other activities. It could also be used to help in training new launch engineers.

Another area to be examined by the working group is in the field of logistics. "The planning and scheduling operation that goes on in the cargo world seems to be a good candidate," said Delaune.

The KSC working group is also exploring the possibility that an expert system can be developed to provide reliable 12-hour weather forecasts for the vicinity.

How well can the computers be expected to do? "Generally, these systems tend to be very reliable in a limited domain," he said. Delaune used as an example a Stanford-developed system which can recommend prescription drugs for the treatment of illnesses described by symptoms. "It seems to be better than the people that created it," said Delaune. "It's more consistent than they are. It never forgets any of the things they taught it."

A computer system may prove invaluable in loading the Shuttle's main tank (the dark cylinder in the picture) with propellant. *NASA*



TENMA: JAPAN'S X-RAY SATELLITE

By Clive Simpson

Japan's second X-ray astronomy satellite, Tenma, was successfully launched on 20 February 1983 by the Institute of Space and Astronautical Science (ISAS). It was the eighth in a series of scientific satellites put into orbit by the Japanese. The author provides a basic description of the satellite and its mission.

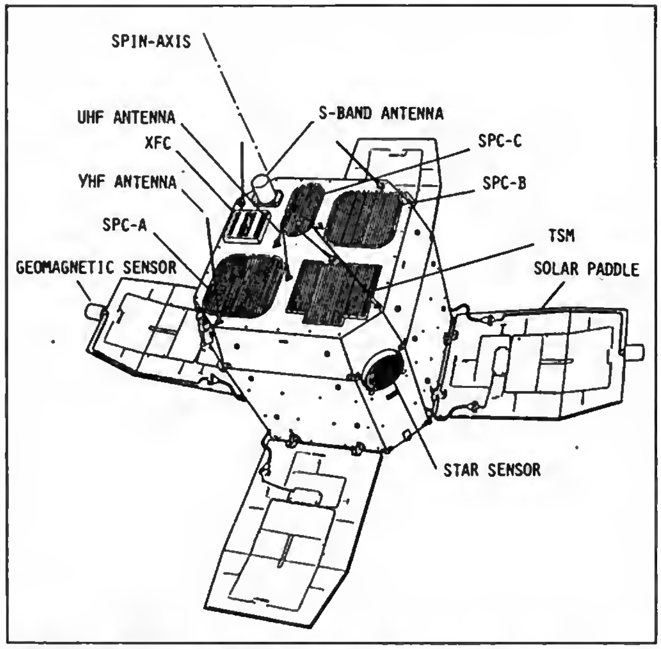
Introduction

It is hoped that Tenma (a name synonymous with Pegasus) will answer some of the many questions posed by Japan's first X-ray satellite, Hakucho, which produced significant results in both X-ray and neutron star astrophysics. A major objective of Tenma is to address some of the remaining critical questions relating to neutron stars.

Tenma has better temporal and spectral sensitivity for the observation of fainter sources. Its main instrumentation is a set of ten gas scintillation proportional counters with twice the energy resolution of conventional proportional counters.

The spacecraft body is an approximate cube of 89.5 cm in height and 110.4 cm in width, weighing about 218 kg. Four solar panels provide maximum electric power of 150 W, with the region of sky which can be observed at any one time being limited mainly by power constraints.

Launch of Tenma (previously known as Astro-B) on 20 February 1983. *ISAS*



The main features of Tenma. See the text for the meaning of the abbreviations. *ISAS*

Tenma is a spin-stabilised satellite, though if required its angular momentum can be carried by a momentum wheel.

Attitude manoeuvres are performed by activating a magnetic torquing coil, with a typical 20 degrees transfer taking several orbits. The resulting attitude is measured using Sun, geomagnetic, horizon and star sensors. It can also be measured from some of the X-ray detectors observing the positions of known X-ray sources.

The orbit, with an inclination of 31.5 degrees, is circularised 500 km above the Earth. The period is about 94.5 minutes and ground contact is available for five consecutive orbits out of 15 per day.

The Instruments

The four high energy astrophysical experiments carried by Tenma are:

1. Scintillation Proportional Counters (SPC) for the spectral and temporal studies.
2. An X-ray Focusing Collector (XFC) for the study of very soft X-ray sources.
3. Transient Source Monitor (TSM) for wide-field monitoring of the sky.
4. Radiation Belt Monitor/Gamma-ray Burst Detector (RBM/GBD) for monitoring of the non-X-ray background, an alarm for the South Atlantic Anomaly, and the detection of gamma-ray bursts.

The SPCs are capable of locating persistent X-ray sources with an accuracy of a few arcminutes, and of continuously monitoring the background variation.

Satellite tracking operations and a quick-look check of X-ray and housekeeping data are performed at the Kagoshima Space Center in Japan. Commands are sent through a 137 MHz up-link whereas the real-time and stored data are transmitted through 400 MHz U-band and 2280 MHz S-band down-links during the ground contacts.

The Japanese are looking forward to a substantial return from this eighth scientific mission, a figure alone which must be regarded as a significant achievement in the country's relatively short history of participation in space exploration.

FROM THE SECRETARY'S DESK

A Matter of Space

The thought that our Society may soon have to contemplate extending its premises (to provide enlarged member-services rather than offices) reminds me that in April 1969 the BIS Council envisaged that of our space requirements would range from a "modest" 3,000 sq.ft. to a "desired" 5,000 sq.ft. We ended up with something in between, with the 5,000 sq.ft. as desirable now as ever at it was.

By 1973 conditions had become intolerable. The first meeting of the newly-formed Premises Committee took place on 14 April and, after some years of searching, our present premises came on the market and were inspected for the first time on 6 November 1975.

As regards funding, the air was thick with suggestions. Trusts and charities were to be approached, Government cash was available, etc, etc. The plain fact was that those bodies with cash were hanging on to it like grim death. Not only was not a penny received, but we were sometimes actively dissuaded from going any further. An example of this concerned plans to establish our specialised space library. Substantial Government funding for libraries was available, ostensibly for such a purpose, but the message came through loud and clear, "there are plenty of libraries already which have all the facilities to provide space material; your library will be pointless."

No wonder that the ability to grab hold of our own bootlaces still ranks as our greatest asset. Even if not suitable for a Society motto, it certainly has been the key to our success.

Even so, the small problem of finding the money remained. We had sought the advice of a fund-raising organisation in 1964 which suggested a target of £100,000, in return for a real cheque from us of £200 on account and the promise to pay them between 10 and 20% of all monies raised. The latter, apparently, required no effort at all on our part so it seemed like money for jam. Two things eventually happened. First came a draft fund-raising brochure, consisting largely of blank pages. The only thing clearly identifiable was the "£100,000 Appeal" on the front. At that point it began to dawn on us that not only was the actual raising of the money but even the preparation of the brochure were to be done by ourselves! We demurred. In reply, back came an encouraging new brochure, identical to the first, i.e. mostly blank pages, but with one significant difference. The £100,000 had been altered to £200,000.

In truth, as I now recall it, three things had really happened, for between the first and second brochures the fund-raising organiser went skiing in Switzerland and came back with a broken leg. It always seemed to me that that was where our £200 had gone to.

Now, in less than a decade, we have not only renovated our existing offices and made them fully operational but are contemplating yet another step towards that 5000 sq.ft. target envisaged so long ago.

Tidal Wave

Ruminating about things the other day reminded me of the onset of the space age with the launch of Sputnik 1 in 1957. The otherwise breathtaking nature of this event was marred for some by the curious yet instantaneous emergence of "experts" who completely filled radio time, the TV screen and every newspaper and magazine. The lure of the quick buck was irresistable. Whether it was the same in other countries I cannot tell but in the UK, our Society was overwhelmed by sheer weight of numbers. Without access to updated information, it could not instantaneously satisfy the upsurge in public interest. It was a very lean time for the Society, indeed.

It grew even worse with the Apollo flights. Though we laboured night and day to cope, as our postbag totals show: 1967 - 15,000; 1968 - 20,000; 1969 - 35,000 (reflecting Apollo 11 interest).

Those who actively enquired about the Society's wellbeing at that time received a nasty shock. Far from it receiving recognition for its long pioneering efforts, its magnificent past contributions and its unstinted devoted efforts for years on end, the limelight was filled with individuals primed with recently-acquired erudition. Our founders would have been dumbfounded to see this reversal of all that they had anticipated. Space achievement brought not recognition, but near-eclipse.

Strangely, it was a reduction in public interest which gave us a chance to recover, for those with a longer-term interest sought out the Society and thus set it on a growth pattern again.

I still recall it as the day of the publicity-seekers - all those looking for prestige, honour, money or fame.

Unfortunately, they did very well out of it.

Of Local Interest

Joining our Library display case with the 18th century pipes found under our front doorstep (*Spaceflight* Vol. 21, Jan 1979, p.44) are two tradesmen's tokens which probably circulated in the district around the same time. One shows a man in breeches smoking a Churchwarden clay pipe, as found by us, and holding a flagon of ale in one hand and, for good measure, a further barrel under his other! The token coin reads "Sr. George Cook Mayor of Garrat elected August 24th 1796, Fruiterer. Green-grocer. & Oyster Merchant Stangate Lambeth." The other token shows a castle. The backs of both read "Denton Engraver & Printer, 7 Mead Row, Near the Asylum, Lambeth."

The explanation of such tokens is that, in times past, Governments often failed to provide low-value coins *vis* pennies, ha'pennies and farthings, in anything like sufficient quantities. The only course left open to traders was to issue their own coins to fill the gap!

One of the occasions when this took place was in the late 18th century, roughly from 1787-1797. Traders who struck their own pennies and ha'pennies adopted an enormous range of designs depicting such things as persons, coats of arms, local legends or sights, particular events and many similar topics.

Perhaps readers knowledgeable in such matters might care to shed a little further light on our own unusual accessions.

Celestial Ending

Extract from a recent letter;

> "When I die I would like to be taken up into space by the Shuttle and just dropped out and float away."

SATELLITE DIGEST-174

Robert D. Christy
Continued from the May issue

A monthly listing of satellite and spacecraft launches compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

COSMOS 1522-1529 1984-1A-H, 14611-18

Launched: 2009, 5 Jan 1983 from Plesetsk by C-1.
Spacecraft data: Probably spheroidal in shape, around 1 m long, 0.8 m diameter and approx. 40 kg mass.
Mission: To provide tactical communications between troops and units in the field.
Orbit: 1398 x 1461 km, 114.47 min, 74.01 deg (lowest) and 1461 x 1494 km, 115.53 min, 74.01 deg (highest).

COSMOS 1530 1984-2A, 14622

Launched: 1220, 11 Jan 1983 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1511.
Mission: Military photo-reconnaissance, recovered after 2 weeks.
Orbit: 356 x 415 km, 92.30 min, 72.84 deg.

COSMOS 1531 1984-3A, 14624

Launched: 1807, 11 Jan 1984 from Plesetsk by C-1.
Spacecraft data: As Cosmos 1513.
Mission: Navigation satellite.
Orbit: 983 x 1010 km, 105.09 min, 82.94 deg.

COSMOS 1532 1984-4A, 14634

Launched: 1440, 14 Jan 1984 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument unit and cylindrical, supplementary payload at the forward end. Length about 6 m, max diameter 2.4 m and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered or re-entered after 44 days.
Orbit: 167 x 355 km, 89.75 min, 67.13 deg, manoeuvrable.

BS-2A 1984-5A, 14659

Launched: 0800, 23 Jan 1984 from Tanegashima Space Centre by N-II.
Spacecraft data: Irregular cylinder, approx 2 m long and 1.25 m diameter with dish aerial at one end. Power is provided by a twin panel solar array with an 8.95 m span. Attitude control is provided by 3-axis reaction wheels.
Mission: Direct broadcasting of TV signals at K-band frequencies. Specific mission objectives are to provide TV to remote islands and mountainous regions within Japan and to prove the direct broadcasting satellite concept.
Orbit: Geostationary above 100 deg east longitude.

COSMOS 1533 1984-6A, 14666

Launched: 0850, 26 Jan 1984 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1532.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 348 x 414 km, 92.20 min, 70.37 deg.

COSMOS 1534 1984-7A, 14668

Launched: 1203, 26 Jan 1984 from Plesetsk by C-1.
Spacecraft data: Not available.
Mission: Possibly electronic intelligence gathering.
Orbit: 468 x 516 km, 94.47 min, 65.84 deg.

CHINA 14 1984-8A, 14670

Launched: 1210, 29 Jan 1984 from a new Chinese launch site, possibly by Long March 3.
Spacecraft data: Not available but possibly an instrumented rocket stage.
Orbit: Initially 347 x 408 km, 91.92 min, 31.00 deg then manoeuvred to 360 x 6474 km, 160.64 min, 36.06 deg by a major engine firing, later raised to 402 x 6583 km, 162.51 min, 36.07 deg in further test firings.

OPS 441 1984-9A, 14675

Launched: 31 Jan 1984 from Cape Canaveral AFB by Titan 34D.
Spacecraft data: Not available.
Mission: Either a missile early warning satellite or a military communications vehicle.
Orbit: Geosynchronous.

COSMOS 1535 1984-10A, 14679

Launched: 1738, 1 Feb 1984 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in a drum-shaped solar array. Length and diameter both about 2 m, and mass around 700 kg.
Mission: Navigation satellite.

SHUTTLE 41B 1984-11A, 14681

Launched: 1300*, 3 Feb 1984 from the Kennedy Space Center.
Spacecraft data: Delta winged orbiter *Challenger*, length about 37 m, and span 24 m, with mass around 70 tonnes.
Mission: To launch two commercial satellites and to carry out a number of tests prior to the April 1984 Solar Maximum Repair mission. The two satellite launches were unsuccessful. Astronauts Bruce McCandless and Robert Stewart completed test flights of the Manned Manoeuvering Unit but the launch and retrieval of the SPAS-01 pallet satellite were not carried out due to a failure of the robot arm. Rendezvous tests with a small balloon were also cancelled because of its failure to inflate. The mission was commanded by Vance Brand and fourth and fifth members of the crew were Robert Gibson and Ronald McNair. *Challenger* landed on the Kennedy Space Center runway at 1216, 11 Feb, the first Orbiter to do so.
Orbit: 306 x 322 km, 90.61 min, 28.46 deg.

WESTAR VI 1984-11B, 14688

Launched: 2059*, 3 Feb 1984 from the payload bay of *Challenger*.
Spacecraft data: Standard Hughes HS376 vehicle, cylindrical, with length about 2.8 m and diameter about 2.16 m. Mass (with fuel) about 1200 kg.
Mission: To provide communications for use by Western Union. The satellite failed to reach the intended geostationary orbit due to insufficient thrust, possibly due to a failure in the nozzle of the Payload Assist Module.
Orbit: 303 x 1216 km, 99.83 min, 27.67 deg.

PALAPA B2 1984-11D, 14692

Launched: 1637*, 4 Feb 1984 from the payload bay of *Challenger*.
Spacecraft data: As Westar VI.
Mission: Communications for the Indonesian government. The mission suffered the same failure as Westar VI.
Orbit: 277 x 1186 km, 99.24 min, 28.16 deg.

OPS 8737 1984-12A 14690

Launched: 5 Feb 1983 from Vandenberg AFB.
Spacecraft data: Not available.
Mission: Possibly three payloads carrying out radar surveillance.
Orbit: Not available.

COSMOS 1536 1984-13A, 14699

Launched: 0924, 8 Feb 1984 from Plesetsk by F vehicle.
Spacecraft data: Not available.
Mission: Possibly electronic reconnaissance.
Orbit: 634 x 665 km, 97.78 min, 82.54 deg.

UPDATE: Cosmos 1500 (1983-99A) is an Earth resources-type satellite with particular emphasis on studying the oceans.

BOOK NOTICES

The Return of Halley's Comet

P. Moore & J. Mason, Patrick Stephens Ltd., 8ar Hill, Cambridge, CB3 8EL, 121pp, 1984, £7.95.

This book sets out not only to recount some of the history of Halley's comet but also to provide readers with an up-to-date account of these mysterious objects and what is known about them so far. It also details progress with space probes and arrangements made *via* The International Halley Comet Watch for amateurs to participate in studies of this distinguished visitor.

The return of Halley's comet will surely promote enormous interest both in comets and meteors generally, aided and abetted, no doubt, by the information which will flow from Giotto and other comet probes. Comets are thought to be composed of some of the most primitive matter in the Solar System, with nuclei of so-called "dirty ice," material which might prove particularly interesting because it could provide further clues as to the origin of the Solar System.

Catalogue of Cometary Orbits

B.G. Marsden, Enslow Publishers, P.O. 8ox 38, Aldershot, Hants, GU12 6BP, 96pp, 1984, £8.50 (inc. postage).

This handy volume tabulates data on the orbits of 1109 cometary apparitions observed from 240 BC to May 1982, prepared from computer copy by the Central Bureau for Astronomical Telegrams of the IAU.

For easy reference the catalogue is devided into six sections for, in addition to the usual orbital elements, sections include information such as observational intervals, number of appearances of periodic comets and non-gravitational perameters. Low-precision statistical tables are also provided to supplement the basic catalogue and a section added containing unusual circumstances or information about particular comets.

Spacelab

Walter Froehlich, NASA EP-165, 1983, $7.

The highly successful Spacelab 1 mission late last year provided a timely reminder of how far space flight has come since the pioneering days of Gagarin and Shepard. Non-astronaut science specialists can now fly into space to conduct experiments in a strange new environment. Spacelab 1 demonstrated just how much work a six-man crew can pack into a ten day mission.

The author, a long-standing member of the Society, has done an excellent job of introducing the Spacelab concept and its actual construction and operation. A profusion of colour photographs and diagrams lead the reader inside the laboratory to look at how it works and *why* it is necessary. The non-technical text describes a typical mission while a large portion of the book concentrates on the experiments and people of the first flight. The continuing forays into space make it an ideal candidate for updating at least every two years.

The Illustrated Encyclopedia of Space Exploration

R.S. Lewis, Salamander Books, 27 Old Gloucester Street, London WC1N 3AF, 320 pp, 1984, £12.95.

This is not an encyclopedia arranged in alphabetical order but a collection of essays by a number of contributors which, packed with illustrations, provide a fully up-to-date account of man's discoveries in space in a largely astronomical context and stemming, essentially, from recent developments in space-borne instrumentation. Particularly attractive are the 32 double-page spreads which reproduce some of the finest pictures yet returned from space. The fact that the volume contains more than 500 colour and black and white photographs, diagrams, etc., besides 20 detailed colour cut-away drawings of spacecraft, indicates the enormous amount of time and effort which has gone into the "visuals." The result: almost every page is in colour. Model-makers, particularly, will find these special layouts extremely useful. The text is arranged in four main parts. The first is on the origin and evolution of the Universe, stars and our Sun; the second goes on to deal with the origin of the Solar System and then to examine the major planets in detail. The third part really advances the space cause, indicating its role as a new industrial frontier and the resources that one might expect to develop, coupled with the development of the necessary launch vehicles and suitable programmes. The final part is more in the nature of an appendix, listing major space milestones in diary form for each year.

This is a beautiful book to possess, especially as it contains a number of pictures which have not received wide publicity before.

Where Will We Go When the Sun Dies?

J.W. Macvey, Patrick Stephens Limited, 8ar Hill, Cambridge, CB3 8EL, 264pp, 1983, £16.95.

Those concerned with disasters of various sorts will find much in this book to commend it. That the Sun will one day become a nova or otherwise alter its benign complexion so that the Earth becomes uninhabitable is almost bound to occur. This prospect has led to a book which presents a fascinating survey of what is known about some of the relatively close stars which might possess planets suitable for colonization and thus afford an escape route.

Besides discussing the probable life span of the Sun, the author enters into many other speculative realms e.g. the possibility of intelligent life on other worlds and the idea of interstellar "arks" to make the long journeys to other star systems. The planets of other stars, or even the creation of artificial planets, may present refuge. The author addresses himself to such problems as how much time mankind has left before the inevitable solar rampage; when will humans begin their first interstellar journeys - what will be the means of travel, etc.

It is certain that our Sun will eventually die, though whether this will be quietly and with plenty of warning, or a split-second cataclysm, is not possible to determine. Eventually, however, man will need to flee the Earth so it is not a question of "if" but "when," for even the Earth itself will not last forever.

In fact we may even have no need to worry unduly about the Sun. According to the famous story by the late Sir James Jeans, the Moon may well spiral in, disintegrate, and thus clobber us first.

The book contains many references of Daedalus as a forerunner of interstellar travel though those following up the reference to "Realities of Space Travel" by L.R. Shepherd are unlikely to find it. The Editor was actually our Executive Secretary, L.J. Carter.

Astronomy from Space

J. Cornell and P. Gorenstein (Eds.), MIT Press, 126 8uckingham Palace Road, London SWIW 9SD., 248pp, £15.75.

Until about 1946, practically everything known about the Universe was obtained from radiation within a small section of the electromagnetic spectrum i.e. the optical window and its near-ultraviolet and near-infrared extensions. Nowadays, many new space observatories are in the planning stages e.g. a large optical solar telescope, infrared telescope, gamma-ray observatory and an advanced X-ray telescope. On the ground,

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Most of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

there are plans to build at least one enormous optical telescope in the 10–15 m diameter range, with radio astronomers proposing an array of radio telescopes to span the US and achieve a spatial resolution equivalent to that of a single telescope 4,500 km across.

The current volume explores and reviews recent knowledge, beginning with a summary of the state of astronomy before the space age and leading on to examination of the Sun, Moon and planets, and then into deep-space.

Manual of Satallita Communications
E. Fathenakis, McGraw-Hill Book Co. (UK) Ltd., Shoppenhangers Rd., Maidenhead, Berkshire SL6 2QL, 351pp, 1984, £30.50.

Satellite communications nowadays play a key role in a wide variety of important areas, from global strategic defence to the deregulation of the communications industry. This book presents, in one concise yet comprehensive volume, much of the material necessary for a thorough understanding of both theory and design practices in these areas. Throughout, the book emphasizes the concept of the total communications service, by pointing out that end-to-end (not just the space link) should be the foremost consideration and the prime function of communications satellite systems.

The design of a good, reliable satellite communication system presents signficant challenges. Low available signal power, limited bandwidth, nonlinear operation, proximity of adjacent channels, high cost, severe weight restrictions and inaccessibility for maintenance are only some of the technical problems involved, with restrictions stemming from government regulations and national interests further complicating the task.

The material in this book is based on lectures used in a first-year graduate course prepared for engineers just starting their careers in the satellite communications industry and who, therefore, had little practical experience.

Besides providing an historical summary over the past several decades, as well as spacecraft that carry the communications payload, much of the text is concerned with system description, deployment and cost, besides the Earth and space links, including the characteristics of voice, video and data channels.

Physics of Meteoric Phenomena
V.A. Bronshten, D. Reidel Publishing Co., Voorstraat 479-483, P.O. Box 17, 3311 CV, Dordrecht, Netherlands., 356pp, 1983, $74.

This monograph, an English version of a Soviet volume published in 1981, deals with the complex physical events accompanying the entry into the Earth's atmosphere of meteoric bodies, i.e. small objects in the range of 10^{-12} to 10^{12} grams, which interlock with air molecules and thus produce a "shooting star" or meteor. Ionised columns of gases are formed along the path of the meteor which reflect radio waves and which are observable by radar. The limiting sensitivity of present-day radar makes it possible to record meteors down to a stellar magnitude of $+14$, though the most brilliant bolides can reach magnitude -19.

The meteoroid's atoms, evaporating from its surface due to the intense heating, also radiate, so that subsequent spectral observations of bright metaors can provida valuable information about their chemical composition and tha physical conditions of found in their environment.

The topics discussed in this voluma are of interest not only to those involved in meteor astronomy but also have a bearing on the problems of spacecraft reentry.

Dynamical Trapping and Evolution in the Solar System
Eds. V.V. Markellos & Y. Kozai, D. Reidel Publishing Co., 424pp, 1983, $58.

This book contains 42 papers delivered at an IAU colloquium in Greece in 1982, divided into six main sections: satellites and planets; comets and meteor streams; asteroids, periodic orbits; trapped motion in the three-body problem and a final section on miscellaneous topics.

The fifth section includes significant contributions to the understanding of the aspects of dynamical trapping in the Solar System's evolution. Many interesting topics emerge e.g. the Trojan group of asteroids is one example of an asteroid "family" which might, one day, escape from their present positions.

Another interesting paper concerns "extinct" comets i.e. those which leave a sizeable core or shell after losing their more volatile components. The end result would probably appear as an asteroid-like survivor, with the minor planet Petulia as a suitable candidate having a cometary origin.

Astronomical Calendar 1984
Guy Ottewell, c/o Dept. of Physics, Furman University, Greenville, SC 29613, USA, 65pp, 1984, $10.

This is not a wall-hanging calendar but a large format (28 x 35 cm) month-by-month series of charts showing what is to be seen in the northern night skies during 1984. Each month is allocated a double page spread with a hand-drawn sky map and the positions of the Moon and planets marked for that period.

The rest of the calendar is devoted to Meteors, Jupiter's satellites, Asteroids, Comets (including Halley's Comet), together with a glossary and a description of how to use the volume.

The Star Book
R. Burnham, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 2RU, 17pp, 1984, £3.50.

This is not so much a book as a set of spiral-bound loose-leaf charts easy to use in the amateur's backyard on starry nights. Eight charts, each measuring 285 x 155 mm, take the beginner through the basic features of the northern skies for the seasons of the year, for the volume is not tied to 1984 phenomena.

Facing pages describe what is to be found, concentrating more on the layout and mythology of the constellations. It would form an appropriate gift for someone just beginning to learn the patterns of the night skies, even though it is unusual to see Orion depicted as a 'square' rather than a belted figure with a waist!

It would have been handy to have included some indications of planetary positions for the next few years. The introduction avoids this simply by saying, "Instead, you have the fun of spotting them yourself!"

Editorial
Continued from p. 241]

Up to the present the commercial exploitation of Space could be described as introversive, involving as it does aids to surface activities such as: telecommunications; meteorology; navigation and Earth-resources surveys. However important these may be, they will be far surpassed in scale by the more ambitious enterprises that have been outlined. The initial step in this burgeoning Twenty-First Century commerce in Space will be the establishment of extensive coherent orbital facilities (space stations) in the close vicinity of the Earth. These, in addition to their uses as micro-gravity fabrication and processing facilities will be the bridgeheads for operations in deeper space. Lunar bases will follow and then the remote stations which Man will set up to exploit the vast resources of the Solar System and which will extend his frontiers hundreds of millions of miles beyond his native sphere.

Participation in this great enterprise will be vital to any major community wishing to remain in the forefront of human endeavour and avoid sliding back into a state of frustrating decadence. But there is an entrance fee, in money, resources and effort, paid by all who wish to participate. Already, the USA and USSR are moving resolutely into this second phase of Man's advance into space with their steps towards the establishment of ambitious orbital stations. Other communities or groups of communities, such as the nations of Western Europe, must match these efforts if they want to share the benefits which will accrue from this extension of Man's domain.

The Brighton Pavilion will be included on a special Ladies' Programme being organised for Space '84.

The Society will once more be using Brighton as its Space venue because of the excellent Conference facilities. Brighton has been on its toes to cater for conference business for many years now and has grown to one of Europe's largest centres during the past decade. Our venue, The Brighton Centre, opened in 1977. It is a multi-purpose building packed with specialist features which make it indispensible for large meetings such as Space '84. We will be using the Foyer Hall, as for Space '82, which everyone found so satisfactory and with the huge Main Hall, once again, reserved for the Banquet.

The Foyer Hall seats up to 800 people although we want to keep numbers down to about half that, so that everyone has plenty of room (plus exhibits, etc.). The Main Hall – if we needed it at some future time – provides a 5000 seat capacity with translation and TV/radio facilities also available and with many smaller 'seminar' rooms to hand.

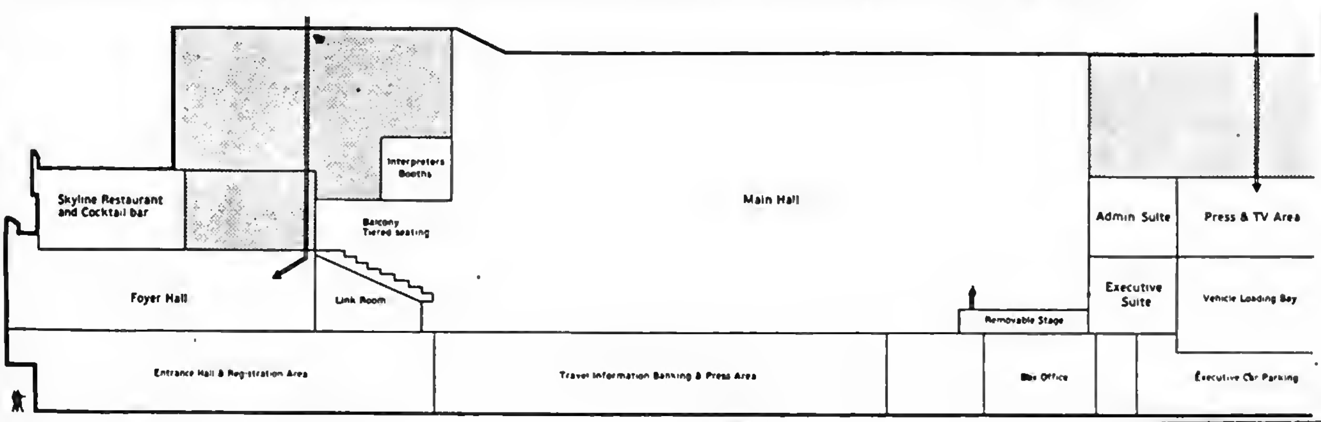
Brighton is easy to reach. Gatwick airport – with links to 125 cities around the world – is only 30 minutes away, with the M23 connecting to Brighton on one hand and London on the other. Accommodation, ample and varied, ranges from the small guest houses to the first class hotels. A large selection of theatres, restaurants and clubs ensures there is plenty of night-time activity.

There is always plenty to see during the breaks at Space '84. The most famous of all Brighton's attractions is surely the Royal Pavilion, completed in 1822 by the Prince Regent. This is one of the stops of the Space '84 ladies programme (more details will be available later). Just a minute's walk away are the 'Lanes,' in the traditional heart of Old Brighton. Theses are a tangle of small by-ways filled with antique shops, pubs and restaurants.

16-18 November 1984

SPACE '84

Below: A schematic of the Brighton Centre. The dimensions have been distorted to squeeze several floors on to one diagram.



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Correspondence, manuscripts intended for publication and requests for information on membership may be addressed to the Executive Secretary at the Society's Offices at 27/29 South Lambeth Rd., London SW8 1SZ. Tel: 01–735 3160.

NOTICES OF MEETINGS

Full details on some of the meetings listed below are to be found inside the magazine.

Lecture

Title: **ASPECTS OF ROCKET TECHNOLOGY**

by Martin Fry
Chairman, *BIS Programme Committee*

To be held in the Society's Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ, on **16 May 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

Lecture

Title: **DISCUSSING SPACELAB**

by Dr. D.J. Shapland
ESA, Directorate of Space Transportation Systems

An overview of the Spacelab 1 mission, by one of our Space '84 speakers, with a short film of the flight.

To be held in the Society's Conference Room, 27/29 South Lambeth Rd., London SW8 1SZ on **30 May 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

Technical Forum

To be held in the Society's Conference Room, 27/29 South Lambeth Rd, London, SW8 1SZ on **Friday, 1 June 1984**, 6.30–9.00 p.m., and **Saturday, 2 June 1984**, 10.00 to 12 noon and 1.30–3.30 p.m.

Topic: **THE SOVIET SPACE PROGRAMME**

It is anticipated that papers will be given at the Friday evening and Saturday afternoon sessions, with some Soviet space films being shown during the Saturday morning session.

Offers of papers are invited. Further information may be obtained from the Executive Secretary of the Society. Members with a special interest in the Soviet space programme are invited to attend. A registration fee of £3.00 is payable. Forms are available from the Executive Secretary on request, enclosing a stamped addressed envelope.

Lecture

Title: **THE WORLD OF COMETS**

By Mike Hendrie

Our knowledge of comets has increased greatly over the past few decades and the Halley apparition will add much to it. Why are comets so slow to give up their secrets and how have astronomers tackled the difficulties of observation?

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **6 June 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Lecture

Title: **APPLICATIONS OF ARTIFICIAL INTELLIGENCE TO SETI AND CETI**

by Tim Grant

The third of three lectures on artificial intelligence in space exploration. This lecture considers applications to the search for (and communication with) Extra-Terrestrial Intelligence and their artifacts.

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on 27 June 1984, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

35th IAF Congress

The 35th Congress of the International Astronautical Federation will be held in Lausanne, Switzerland on **7–13 October 1984.**

Theme: **SPACE BENEFITS FOR ALL NATIONS**

Members of the Society wishing to present papers are asked to notify Dr. L.R. Shepherd, Chairman of the BIS International Liaison Committee at Society HQ as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

Space '84

The Space '84 "weekend" will be held in Brighton on **16–18 November 1984.** See inside this issue for details.

LIBRARY

The Library will be open to members from 5.30 to 7 p.m. on the following dates:

16 May 30 May
6 Jun

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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VOLUME 26 NOS. 7 & 8

SPACE '84

16-18 November 1984

SPACE — THE FUTURE OF MANKIND

Our programme for Space '84 at the Brighton Centre introduces a wide variety of space experts covering a wide range of space subjects.

The meeting will be divided into sessions on: New Frontiers, Discovering the Universe, Foothold in Space, Energy and Resources, Advancing Frontiers, the Future of Mankind and Workshop.

The preliminary programme is as follows:

Dr. G. E. Mueller	:	Space: The Future of Mankind
Dr. W. I. McLaughlin	:	The Philosophy of Extra-terrestrial Intelligence
Prof. M. Rees	:	Space Astronomy
Dr. J. K. Davies	:	New Eyes in Space
D. L. Pivirotto	:	Space Platforms and Autonomy
I. Bekey	:	Space Tethers
L. Blonstein	:	Steps to Space
Dr. D. G. Shapland	:	Spacelab
Dr. J. T. Houghton	:	Remote Sensing of the Oceans
C. Honvault	:	Operational Meteosat
J. Casani	:	Project Galileo
R. P. Laeser	:	Voyager: Now to Neptune
Dr. A. R. Martin	:	Space Resources and the Limits to Growth
R. M. Jenkins and D. C. R. Link	:	Giotto Update
Dr. G. Haskell	:	Asteroid Probe
S/L R. M. Harding	:	Space: Human Physical and Mental Adaptability
Dr. R. C. Parkinson	:	Space Colonisation
A. T. Lawton and P. Wright	:	Monopoly: Advanced Propulsion for the Future
R. Gibson	:	European Involvement in Space Station Development
H. Joyce	:	Space Radar Systems
G. Whitcomb	:	Missions for ESA's Science Programme

Remember: this is only a preliminary programme and changes will inevitably occur. Further details will be published in *Spaceflight* and *JBIS* as they come to hand.

Civic Reception and Banquet

A Civic Reception (dance/supper) by courtesy of the Brighton Corporation will be held in the Brighton Centre on the Friday evening to give everyone an opportunity to meet before the conference proper begins.

Highlighting Saturday's social activities will be a Banquet with Guest Speakers Sir Peter Masefield, Ted Mallet and Patrick Moore. The aperitif, 4-course meal and half bottle of wine per person will be provided at a cost of £18.00 per

To keep the friendly atmosphere of Space '82, the number of places available will be held down to 400. Experience shows that these will soon be snapped up, so early application is essential. Simply fill out the form below and send it to The Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

SOUVENIRS OF THE OCCASION

Space '84 souvenirs will take the form of commemorative mugs and decanters all embossed with the Society's motif and the Space '84 logo added for those who would like this too.

Several types are available: pint sized tankards at £10, and half-pint tankards at £3. Special silver-handled half-pint tankards in presentation boxes are available at £7.50. Decanters at £25 are also available.

Post orders will be accepted from members unable to attend our conference personally. These orders (UK only – sorry but we can't run the risk of damage in sending abroad) should be sent direct to:

The British Interplanetary Society,
27/29 South Lambeth Road,
London, SW8 1SZ.

Ladies Programme

Two special Ladies Programme excursions have been arranged for Space '84. On Saturday 17 November, there will be a private tour, with coffee, of the historic Royal Pavilion in Brighton itself. Sunday 18 November, will see an all-day tour by luxury coach to famous Arundel Castle in the morning, a visit to the House of Pipes and lunch at Barnsgate Manor.

Full details on both of these days' events are available from the Executive Secretary. Early booking is essential.

Yes, please send me a registration form and other details on Space '84. I enclose a 20p stamp.

Name: ....

Address: ....

spaceflight

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Founded 1933 *Incorporated 1945*

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CONTENTS

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TWENTY YEARS OF EUROPEAN SPACE CHALLENGES AND OPPORTUNITIES

We congratulate the European Space Agency (ESA) on reaching the 20th anniversary of the creation of the European space movement. These 20 tumultuous years have brought both disappointment and achievement. As ESA stands poised able to accept the American offer of involvement with the exciting Space Station programme yet lacking the political will to do so, we may pause to review current European space achievements.

The Giotto probe, designed to slide through the coma of Halley's comet, could be a forerunner of deep space exploration. AGORA, a proposed asteroid mission, would be a logical follow-on. Long-standing involvement in the communications space programme will see a new dimension with the advent of Olympus, a multi-purpose satellite platform designed to meet a wide range of future mission requirements, due for launch to geostationary orbit in 1987.

With Spacelab, ESA undoubtedly has a commercial resource. The first mission flew 70 experiments, exceeding, in payload weight, the combined total of all the ESRO-ESA satellites put up in the last 20 years. It provides both a versatile laboratory and observational facility which could reduce, significantly, both the time and cost required for future space experiments.

Cooperation with the US, in the form of a 15% stake in the Hubble Space Telescope, underlines the fact that, eventually, the input of new astronomical knowledge will swamp all other programmes. The main mirror on the HST, if enlarged to 4000 km across, would have its largest surface irregularity just 2 cm high, such is its state of perfection. The HST will push back the boundaries of the Universe seven-fold in every direction, make measurements of the diameters of many of the nearer stars and probably reveal Jupiter-sized planets revolving around them. Requests for its use are already ten times greater than can be accommodated. Surveying the whole sky with just one HST would take 20,000 years, thus pointing to the need for even more extensive astronomical Space Platforms.

ESA is undoubtedly now at a crossroads. It has a worthy task and enormous opportunities in developing a range of space programmes over the next 15-20 years designed to make European Industry ready to take the maximum advantage of opportunities as future generations of requirements emerge, but its political problems are immense. To what extent these may be resolved we cannot yet tell.

What thinking man can doubt that our future lies in space? We look more and more towards space to provide our communications, navigation, weather forecasting and remote sensing services. Ahead lie weather control, solar power supplies and new manufacturing and research facilities. The opportunities for man in space grow daily, and not only for specially trained astronauts.

ESA faces both a challenge and an opportunity. It has already shown that it can take up the challenge, but will its political masters give it the opportunity?

COVER

Comet Kopff has been selected by NASA's Solar System Exploration Committee for a rendezvous mission in 1994 with the first of the new Mariner Mark II probes. Discovered in 1906, Kopff has been observed on 12 of its 13 returns to perihelion. The negative image shown here was taken on 13 August 1983 with a 4 m telescope at Kitt Peak National Observatory in the US. This mission, and other advanced concepts, are described in this August's special "Solar System Exploration" *JBIS* issue.

THE CONQUEST OF MARS

By Leonard W. David*

With the Space Shuttle reaching operational status, manned missions to Mars are technologically achievable, scientifically legitimate, biologically necessary and financially affordable.

The author reviews the reasons for humans voyaging to the Red Planet

Introduction

Mars has drawn our collective imaginations over the centuries more than any other planet. So enamoured were we with Mars in the past that we transformed it into Earth's celestial next-door neighbour, teaming with life. Committed to the belief that it was an abode for intelligent life, the French Academy of Sciences offered a Pierre Guzman Prize of 100,000 francs in 1900 to "whoever succeeded in establishing communication with another world *other than Mars.*" The rules demanded such a caveat, argued the Academy, because contact with intelligent Martians was deemed too easy!

* Editor and Programs Manager, National Space Institute, Washington, D.C.

Mysteries left to ponder. A Viking Orbiter imaged this channel on Mars, thought to be formed by liquid water. Permafrost as well as lakes of water are believed to exist below the Martian surface. If confirmed, Mars as an active reservoir of biological activity is a strong possiblity.

Mars as a planet teeming with intelligent life was bolstered by the turn-of-the century observations and writings of astronomer Percival Lowell. Stimulated by the work of Italian astronomer Giovanni Schiaparelli who, in 1877, reported his discovery of lines across the face of Mars which he termed *canali* (channels), Lowell attempted to explain these "canals." He became convinced that a network of water-carrying canals fed a slowly dehydrating population on Mars.

In more than 20 launch attempts since 1962, 14 Soviet and US probes have headed towards the red planet. Mariner and Viking have been crucial in framing our modern perceptions of the planet. Gone are the fictionalised Martian cities.

What remains, however, is a world of astounding geologic diversity: a polar-capped and rugged land of craters, sand dunes and gigantic extinct volcanoes; of immense canyons and global dust storms; a stretch of territory gouged by river bed-like channels.

Manned flight to the red world may well mean the survival of our species; it is a "down-payment" towards routine interplanetary and, eventually, interstellar travel.

Early Manned Mars Proposals

Between 1961 and 1966, NASA awarded as many as 60 contracts to aerospace companies to look at manned Mars flights. As early as June 1962 a concept was examined for a manned Mars-Venus flyby for 1970-1972. This was 'Empire,' or Early Manned Planetary-Interplanetary Roundtrip Expeditions. By the mid-1960's, NASA studies showed that the Apollo Moon technology was adequate, although such a mission would be expensive, with a long flight time and highly complex.

The then Vice President Spiro Agnew announced at the launch of Apollo 11 in July 1969 his belief that the US "should articulate a simple, ambitious goal of a manned flight to Mars by the end of the century." In 1969, NASA included the Mars Project in its plans.

1982 as a date for the Mars landing was proposed, using Saturn 5 boosters originally designed for Apollo. Two command ships, each holding a crew of six, would be constructed in Earth orbit. The flight would take 600 days, with propulsion by nuclear engines and with nearly a month on Mars. The actual landing would be made with an Apollo-shaped Mars Excursion Module (MEM). The return leg would include a flyby of Venus, with a probe dropped into the clouds.

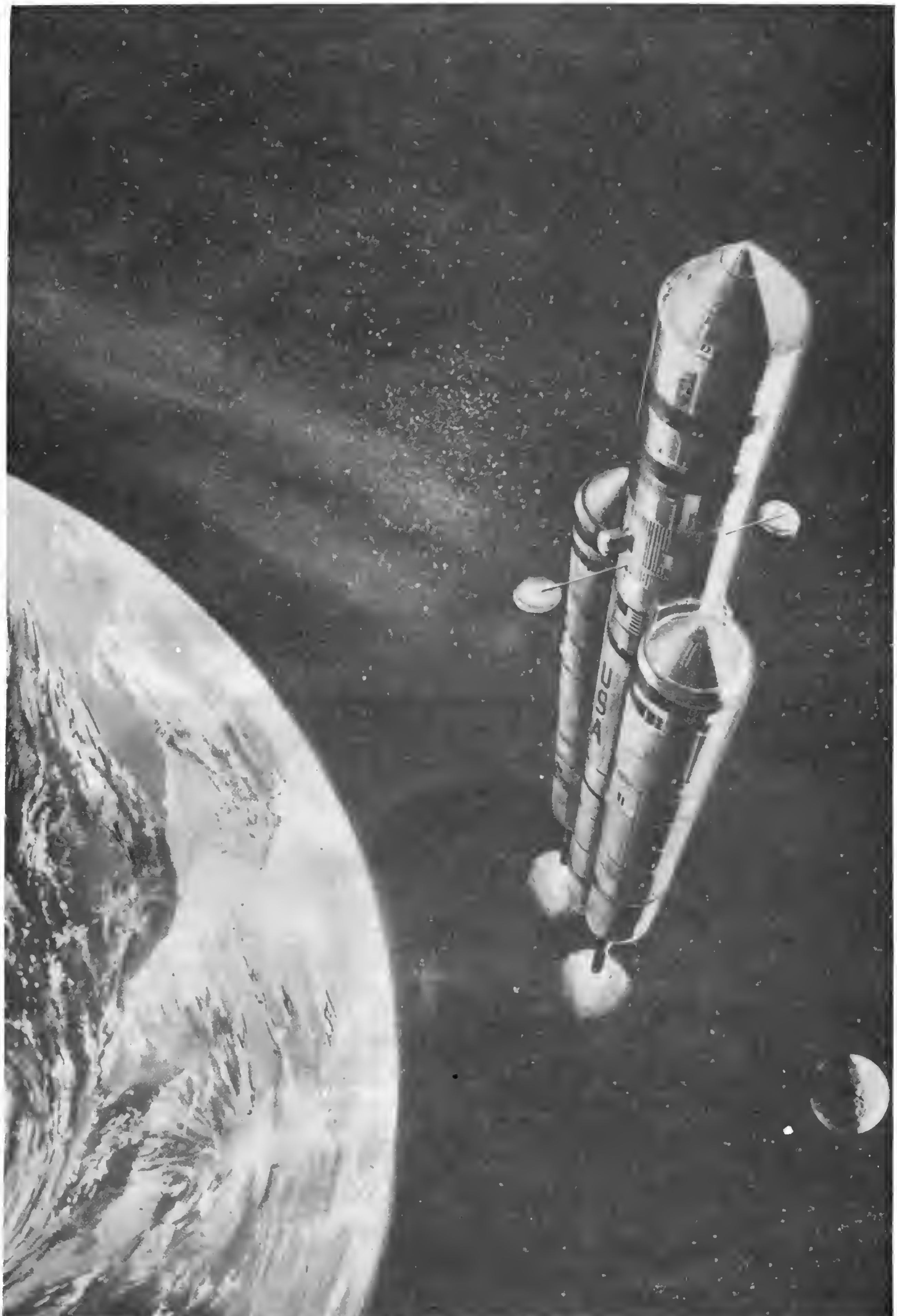
Picked by NASA to spearhead the Mars effort and to sell the proposal to Congress, the late Wernher von Braun argued that the undertaking would represent "...no greater challenge than the commitment in 1961 to land a man on the Moon." Von Braun and Mars became almost synonymous. In 1952, the visionary engineer had outlined one of the first technical proposals for human flight to the planet, simply titled: *Mars Project.*

Reaction to the contemplated Mars objective in the late 1960's was swift and decidedly negative. Little support materialised from the public, Congressional leaders and press. There was no need for a "super-Apollo," argued sceptical politicians. The financial drain of a Vietnam war, shifting economic priorities, and a down-grading of the so-called "space race" - all contributed to the downfall of the Mars project.

Mortal versus Machine

The planting of human footprints on Martian soil has

Facing Page: The 1960's studies of manned expeditions to Mars envisaged the use of Apollo-class technologies. It is time to re-evaluate interplanetary travel based on the wide range of capabilities now emerging from space-faring nations. NASA


USA

been unsurped by a number of US robot emissaries from Earth: Mariners 4,6,7 - 1964 to 1969 (flyby); Mariner 9 - 1971 (orbiting); Viking 1,2 - 1975 (landing). Soviet probes have been far less successful.

With each piece of data returned our understanding of Mars has been enhanced. Through the mechanical eyes of the two Viking landers, and with sensitive mini-laboratories to assess the chances for Martian life, our attention was captured. Yet the statue-like presence of mechanical brethren on Mars is a far cry from a truly human touch.

The Viking search for life on Mars clearly demonstrated the vulnerability of machine intelligence. The landing craft radioed a clear answer to a pre-programmed inquiry: Is there life on Mars? Effectively, the answer was: "Would you repeat the question?"

The promise of artificially intelligent macrocomputers could add significant dimensions to automation concepts. Have we reached the crossroads so that future Mars travel will require mortals, rather than just machines, for maximum scientific return? How much science is *enough* science before humans strut between Martian sand dunes? Is pursuit of scientific knowledge the sole justification for reactivating the potential of human interplanetary travel?

The Return to Mars

Armed with many new questions raised by the Viking programme, numerous studies have been made for returning to Mars with unmanned craft. There is a need for complementary programmes, enabling planetologists to obtain a complete understanding of the planet.

Some suggested projects are:

1. A Mars Orbiter - a less costly probe to circle the planet pole to pole, globally mapping the geological, geochemical, atmospheric and magnetic properties;

2. Sensor outposts - equipment-laden missiles would plunge into Mars shot from an orbiter. 12 "penetrators" might gather surface data on weather and seismic in a global network;

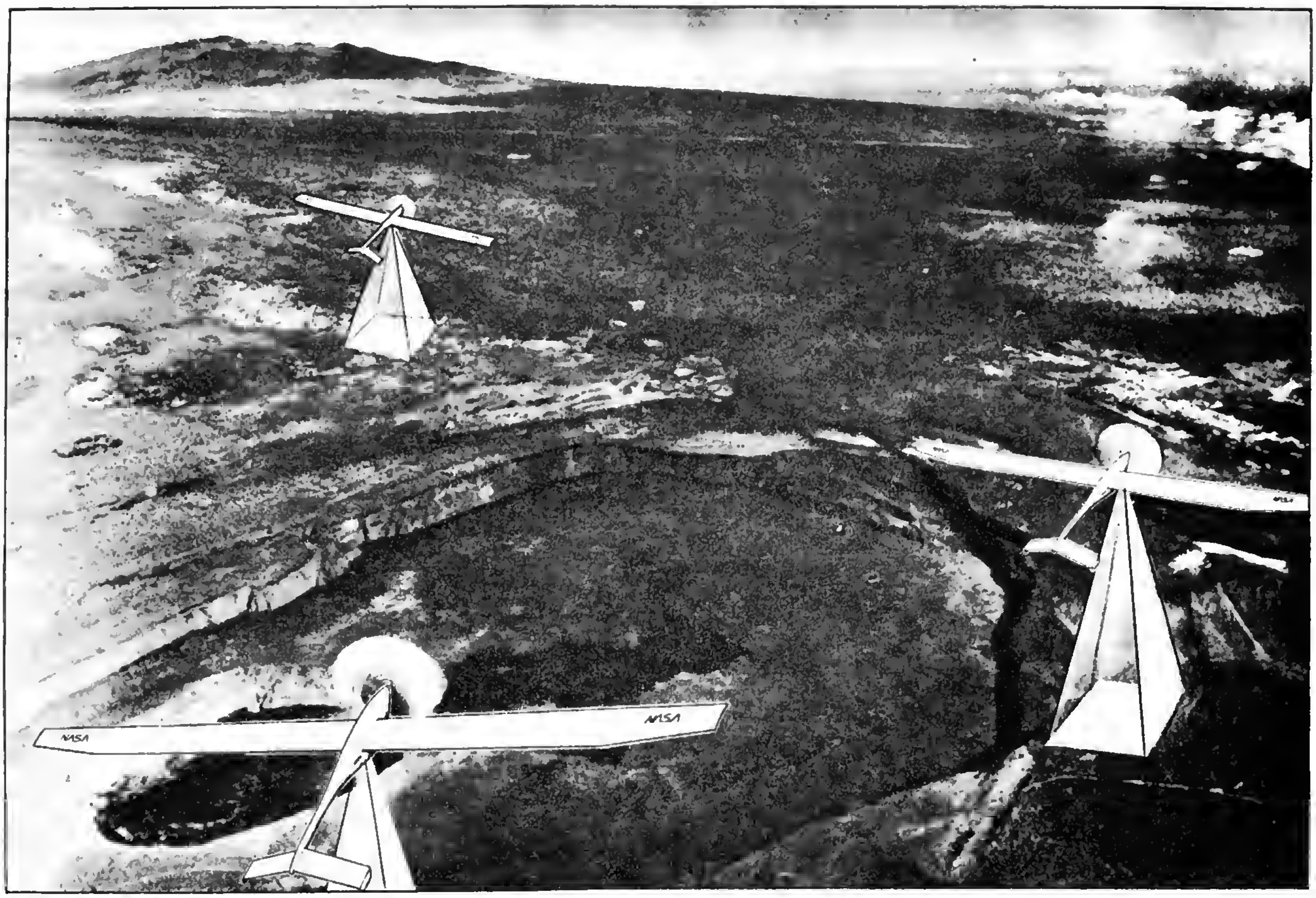
3. The mobile lander - it would rove around, equipped with a variety of sensors. It could look at numerous geological areas of interest and search for life "over the next hill;"

4. A Mars "Air Force" - unmanned, computer-controlled aircraft dispatched from a circling carrier. They could reach any area, their cameras would provide TV audiences on Earth with a pilot's-eye view. Instruments could be deployed at selected sites as well, perhaps designed to scoop-up soil samples;

5. A return sample mission - by far the most costly and complicated approach, a landing vehicle to gather samples, launching them to Earth in a sealed container. The craft could make its own return-propellant from local resources.

Of course, the overriding factor is cost. The mobile laboratory and return-sample concepts are clearly expensive although they might answer the vital post-Viking questions. What is the true cause of the gargantuan channels? Are they dried river beds from a time when tremendous quantities of water flowed there? How thick is the crust and the size of the planet's core? What are

Explorers sally forth from the Mars Excursion Module in this 1969 concept. NASA



The use of unmanned aircraft to survey Martian terrain has been evaluated. Such vehicles - part U-2, part cruise missile - might be deployed from a Mars-circling spacecraft, reaching varying locales on the planet. Future versions could support an astronaut for increased mobility.

the chemical components of surface rocks and mineralogic structure of the soil? And, with the Viking landers shovelling into the Martian ground a mere 25 cm, did they miss deeper permafrost - an important sign for detecting life?

The Humanation of Mars

A manned voyage to Mars could be achieved by "borrowing" from capabilities emerging in the 1980's and 1990's: solar electric and solar sail propulsion, aerobraking and aerocapture techniques, large scale construction in orbit, in-space propellant manufacturing and refuelling, and support platforms and habitable stations.

Barring faster transit times, however, the life-supporting technologies will be stretched. And what about the effects of long periods of weightlessness on the crew, and the psychological impact of the tedious journey?

Following a full unmanned reconnaissance, our ability for safe and scientifically valuable manned exploration will have matured. Coupled to Shuttle operations and their metamorphosis of near-Earth space, a manned excursion to Mars will be within our technological reach. The difficulty, cost and complexity will, in turn, decrease accordingly.

One scenario is a blend of human and automation: human + automation = humanation. Such a concept, leaning heavily towards human capabilities supplemented by machine investigations, would yield knowledge far superior to that provided by lonely robot sensors.

This hybrid approach would enhance our knowledge and subsequent use of Mars tremendously. Upon reaching Mars orbit, a complement of human and mechanical research could be started. Landing teams would be dispatched on a routine basis, similar in concept to the Apollo deploy a number of probes, including the "Mars air force" of robot aircraft. "Penetrators" around the planet would create a sensor network. Soil samples could be brought up - first by robots and then by humans - for detailed study in the ship's decontamination facility. From such a mission, and those that follow, Mars would become our second Earth

"Meism"

Is self-survival reason enough to establish an Earthly human link to Mars? The late Wernher von Braun once said "I say let's do it quickly [the Mars landing] and establish a foothold on a new planet while we still have one left to take off from." Mars = Earth II - the ultimate life insurance policy? The possibility that asteroids and comets have in the past, and could in the future, collide with our Earth, might spur the public to consider Mars as a "back-up" planet, preserving Earth life.

Could Mars, the Roman god of war, be transformed into a target that would foster peace on Earth? A Mars co-op of spacefaring nations would assure that no single nation need bear the finances of the undertaking.

Mars as the "middle-man" of the Solar System could provide easy access to the asteroids between Mars and Jupiter. The mining of asteroids has been widely discussed, as has a manned mission to Anteros. It has been suggested that the two Martian satellites, Phobos (Fear) and Deimos (Panic) may be captured asteroids, thereby adding to the list of supportive justifications to explore and exploit Mars and its moons. Along with their resource potential, asteroids could also provide clues on the origin and evolution of the Solar System. In addition, removal of Phobos away from Mars' Roche limit would ensure that its debris would not hamper future manned

Interstellar Future

Sir, Dr. A.R. Martin's article, "Mankind's Interstellar Future" (*Spaceflight*) February 1984) was deeply fascinating, but is the Delphi method of event forecasting anything more than sophisticated fortune-telling?

After all, this is what the function of the original oracle at Delphi comes down to, *albeit* in accordance with three excellent maxims for behaviour - "Know thyself," "Don't exceed," "The Mean is best." Furthermore, the oracular responses as rephrased by the priesthood were often couched in ambiguous terms so that when prediction went awry they could always say you thought we meant this, but we really meant that. Apart from which, it is a sad fact of human nature that innaccurate predictions are quickly forgotten.

From my own studies as a psychologist, I would guess that the reason why the Delphic oracle became so famous, compared with others then extant in classical Greece, was that the performance the Pythia went through before prophesing placed her in a hypnoidal state which rendered her hypersensitive to the wishes of her supplicants.

The Delphi method of event forecasting is really no better than any of this and in a way is remarkably similar to it. Compare how the Delphi questionnaire is resubmitted with the result that the predictions came closer together. I realise that the anonymity of the proceedings is designed to eliminate just this, but can re-evaluation be distinguished from at least some degree of simply conforming to the mean i.e., saying something which we think the others will want to hear?

As Dr. Martin says, a Delphi should only be used where objective data are unobtainable. But if such is the case, how can even the most informed expert in any particular field be doing other than guessing? Guesswork plus guesswork, however processed, can remain only as guesswork.

W.T.R. BOWLEY
Bracknell, Berks

Dr. A.R. Martin comments:

The result of a Delphi forecast may well be a regression to "the mean is best." However, at each stage in the proceedings the participants are required to justify their opinions and to comment against contrary points of view. Thus, opposing ideas are debated in detail and attempts at rebuttal are circulated. A multi-dimensional dialogue is conducted, whereby (hopefully) well-rounded argument which can be backed up by concrete numbers may sway others. The flavour of this argument is shown by some of the reported comments reproduced in the full version of the paper (*JBIS*, **36**, 509-517, 1983).

This argument, and diversity of opinion, was one of the reasons for conducting the "experiment" in the first place. I wanted to learn what other people thought about various topics connected with Interstellar Studies and gain insight and knowledge from them. I hope that the participants benefitted from this also, and not just myself.

A small amount of statistical analysis was also given in the full paper. It should be remembered that the ranges of data given only represent the inter-quartile ranges and that several participants were still unconvinced, one way or the other, at the end of the experiment. They may be right or the majority may be right. Time will tell, but as I the truth. We may go down in history as visionaries, or as charlatans, but we won't be around to take the bows or the blows. The exercise was worthwhile for me, nevertheless, in that it gave me insight into the thoughts of others and produced material that influenced my ideas and inclinations.

Comets on Roman Coins

Sir, I hope that I can clarify the position regarding the Roman coin recently acquired by the Society. In what follows I mention only coins with comets; there are several others with *stars*.

The death of Julius Caesar in 44BC was marked by a number of portents - Earthquakes, storms, floods and the appearance of a comet. According to the Roman biographer, Suetonius, this comet shone on seven nights and was believed to be Caesar's soul being received into heaven.

The BIS Julius Caesar comet coin.

Another comet appeared in 17BC, in the year of the Saeculer Games (held every 110 years), during the reign of Augustus. In that year coins showing comets were minted by the Emperor Augustus (31BC-AD14) at three different mints.

At the mint of Rome, the moneyer M. Sanquinius minted coins showing a head of Caesar surmounted by a comet. On the other side these coins have either the portrait of Augustus or a representation of the herald who announced the games.

At the other two mints, whose location is uncertain but which may have been at Cordoba and Zaragoza in Spain, Augustus minted coins that show his portrait on one side and a comet with the inscription DIVVS IVLIVS ("The Deivine Julius Caesar") on the other.

All three mints use the appearance of the comet in 17BC to commemorate its appearance 27 years earlier at Caesar's death. Presumably, therefore, the Romans thought it was the same comet appearing in different years.

A.M. BURNETT
Keeper of Coins, The British Museum

Gagarin Medal

Sir, I note that the Federation of Cosmonautics of the USSR recently announced, in commemoration of the 50th anniversary of the birth of Yuri Gagarin (1934-1968), that a medal will be awarded annually in his name for outstanding accomplishments in astronautics. It will be awarded on Gagarin's birth date, 9 March, or on the Soviet Day of Cosmonautics, 12 April (the date of his Vostok flight).

RUEN YOTSOV
Sweden

Daedalus in Print

Sir, With reference to the appearance of the Society and

strip (*Spaceflight,* January 1984, p.10) the background is that the strip is drawn by Sydney Jordan, better known perhaps for the 'Jeff Hawke' series which ran for many years and is remembered (for instance) for its almost exact prediction of the date of the first Moon landing.

I have been contributing story lines to the strip, including one which ran in two segments entitled "The Phoenix at Easter" and "The Nest of the Phoenix." They concerned an extraterrestrial intelligence which was exploring our Solar System with space probes, with analogies to the Daedalus Project used twice to explain what was supposedly happening. The original idea for the story came in part from an exchange between Alan Bond and Arthur C. Clarke at the first BIS Interstellar Conference, so Sydney and I have made a point of giving credit where it is duel

DUNCAN LUNAN
Scotland

The Wresat Satellite

Sir, With reference to John Pitfield's letter in May's *Spaceflight* p.198, according to the publication "Weapons Research Establishment SATellite," issued in November 1967 by the Weapons Research Establishment, the launch vehicle *was* a Sparta:

> "The standard Sparta launch vehicle, incorporating certain structural modifications to accommodate the new payload and cater for the different trajectory, will be used. The vehicle first stage is a refurbished Redstone missile modified to accept two solid propellent upper stages. The complete vehicle is about 70 feet high, 6 feet in diametter and weight of approximately 57,000 lb at launch. The Redstone motor provides a thrust of about 75,000 lb and burns for 122 seconds. The checkout and launch of the booster vehicle will be carried out by TRW Systems on behalf of the US Army Missile Command."

Wresat re-entered at 11.34 hrs GMT on 10 January 1968 over the Atlantic Ocean west of Ireland.

BERT VIS
The Netherlands

Wresat-II

Sir, When I was out in Woomera, I remember seeing the Sparta/Wresat site (which actually had a signboard displayed commemorating the Wresat launch) on my way out to visit the ELDO site. Also I seem to recall somebody out there telling me that Wresat was launched using the spare rocket from the Sparta project.

R. GREAVES
Greenfield, Beds.

Tradesmens' Tokens

Sir, I can add a few further words to the note on the trademens' tokens held in the Library (*Spaceflight* June).

First, there was no such place as "Garratt," still less a Mayor. The circumstances were that people in the area of Garratt Lane formed a kind of club, not only to eat and drink but to prevent encroachment upon their common rights. Most were in low circumstances but they contributed constantly and, thereafter, the President of their club was called the "Mayor of Garratt." For good measure they also dubbed him "Sir."

"Sir" George Cook's coin shows the man holding a small keg. On the reverse are some of the commodities of his occupation, a greengrocer business. Actually, "Sir" George Cook was never even elected Mayor. It was a "Sir" Harry Dimsdale who was elected Mayor on that date, to the chagrin of Cook who then accused Dimsdale of securing election by bribery and corruption.

The maker, Matthew Denton, lived in Mead Row, a small street running between Westminster Bridge Road and Kennington Park Road. In 1796 it overlooked the noted St. George's Fields, made familiar by Charles Dickens in "Barnaby Rudge" as the starting place for the Gordon Rioters. The asylum mentioned was an institution which cared for female orphaned children. Its abode was called "Hercules Pillars," really a converted public house.

Perhaps other readers can identify the smaller coin. It shows a view of a castle with a wreath of leaves.

M.W. WHOLEY
Midhurst, Sussex

REFERENCE

1. *The Token Coinage of South London* issued in the 18 & 19th Centuries by A.W. Waters (Simmons & Waters) 1904.

For Those in Peril...

Sir, I enjoyed Derek Webber's article on "Satellites for the Sea" in the April issue but I feel a little neglectedl I know that he focused on communications satellites but Transit, the navigation satellite that antedates his entire list, is still pretty important to the mariner. Over 7000 commercial ships have Transit nagivators aboard, including ships flying the flags of over 65 nations.

CAPT. ROBERT F. FREITAG
Deputy Director, NASA Space Station Task Force

Capt. Freitag was intimately connected with the Transit programme -Ed.

Knight, not Arrow

Sir, I thoroughly enjoyed re-living the 50th Anniversary Dinner as told in the March issue of *Spaceflight*. The staff are to be congratulated on capturing the spirit of this evening so well in print.

The reference to me on page 98, however, was incorrect. I was Chief Rocket Development Engineer on the *Black Knight* programme, and the 25th Anniversary was of the first launch of *Black Knight*. The Black Arrow programme did not commence until after I moved to the USA in 1963.

CHARLES THARRATT
Louisiana, USA

The Soviet type-G Booster

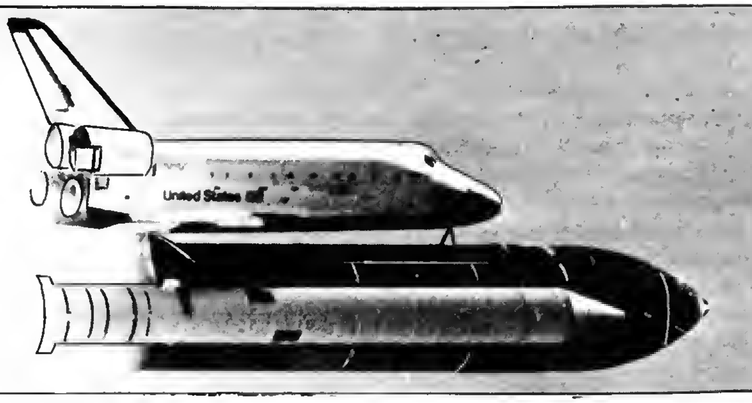
Sir, A comment on the April 1984 issue of *Spaceflight:* The type-G Soviet launch vehicle shown on p.159 was cancelled in 1973-1974. The present large super Saturn class type-G Soviet replacement I call the type-L. It is what will be used for the launching of the Space Station elements: at least that is my expectation. It is a different vehicle from the old type-G, but derived from it.

CHARLES VICK
Maryland, USA

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

SPACE REPORT

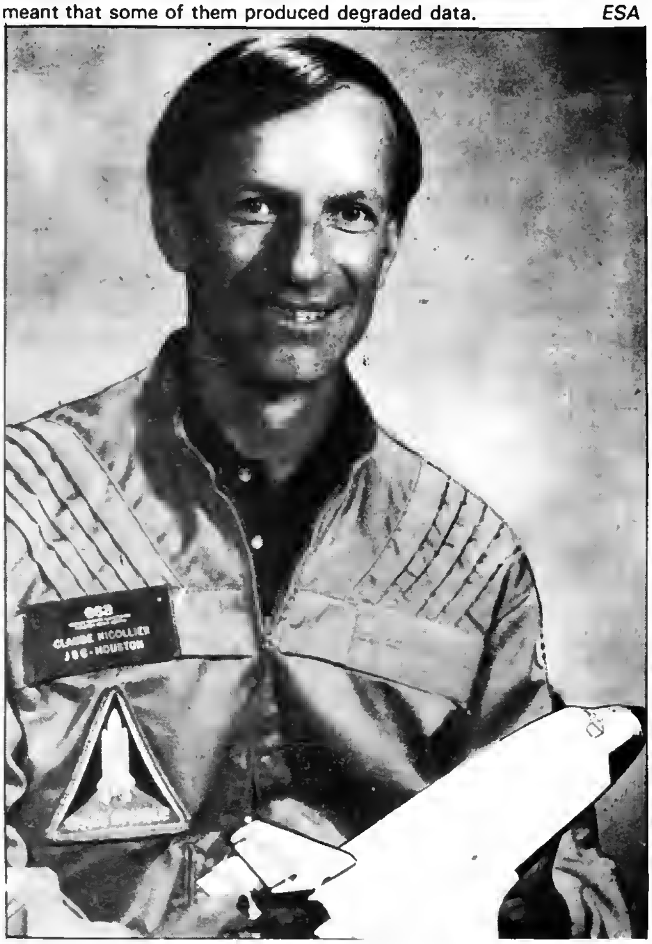
A monthly review of space news and events



CANADIAN ASTRONAUT CHOSEN

Marc Garneau of Quebec City will be the first Canadian astronaut, scheduled to fly along with five US astronauts aboard *Discovery* on 24 October (mission 51–A), writes Joel Powell. Garneau, a 35 year old naval electronic warfare officer, will be understudied by Dr. Robert Thirsk of Montreal, Quebec. The two would-be astronauts are part of a six person (five men and one woman) team announced last December. At least two further flights with Canadian astronauts are scheduled over the next two years. Four experiments will be conducted by Garneau, including background studies for a future Canadian space sickness investigation and a solar photometer to measure atmospheric ozone.

BIS Fellow Claude Nicollier will fly aboard the Shuttle next June as a Mission Specialist in the Environmental Observation Mission 1 (see May's *Spaceflight*, p.223). He was originally chosen to train as a Payload Specialist for Spacelab 1 but then switched to become a full-time astronaut. EOM 1 will carry some of the experiments from last December's Spacelab 1 because the launch delay from September meant that some of them produced degraded data. *ESA*



EXTERNAL TANKS

NASA's Marshall Space Flight Center have awarded a $390 million contract to Martin Marietta for 21 additional External Tanks for the Shuttle. The three-year contract includes manufacturing, assembly, test and delivery of each tank; programme management and administration; and facility operations.

The tank is the largest element of the Shuttle and holds the liquid oxygen and hydrogen for the Shuttle's three main engines.

The company was previously contracted to provide 38 flight tanks; the first 15 have been delivered (11 of which have flown).

THE FLIGHT OF 41F

The 13th Shuttle mission will be the first to carry three major satellites, all of them for commercial customers. SBS 4, Telstar 3C and Syncom 4–2 are communications satellites destined for geostationary orbit 36,000 km high. Syncom will carry its own rocket motor to leave low orbit, while the other two will use PAM–Ds of the type that failed twice during the 41B mission in early February.

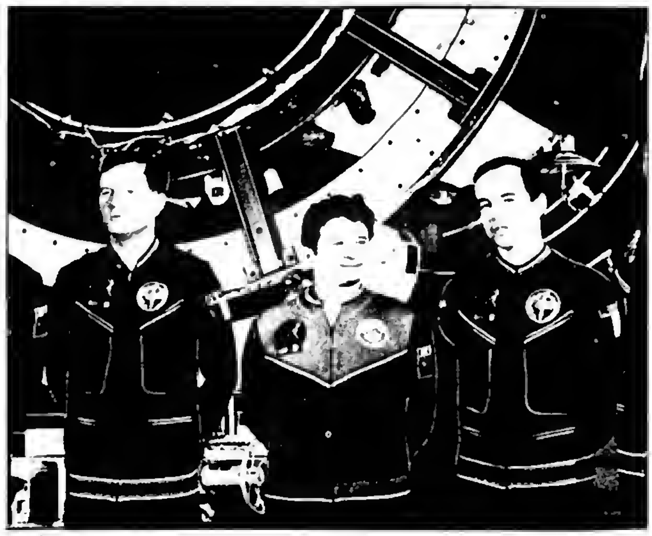
As of early May, the launch is scheduled for 9 August but any delays from Mission 41D in late June could have a knock-on effect. There is also the possibility that the two PAM-carrying satellites could be left on the ground if the causes of the failures are not found in time for the mission.

The four crew members under the command of Karel Bobko are all new to space, each having been selected for astronaut training in 1978. Bobko himself became a NASA astronaut in 1969 after transferring from the ill-fated military Manned Orbiting Laboratory project. He had to wait until April 1983 to make his first space sortie, as pilot on *Challenger*'s maiden flight.

The pilot is Donald Williams, a US Navy veteran of Vietnam and a test pilot. The three mission specialists will be kept busy with the full cargo bay on *Discovery*'s seven day trip. Rhea Seddon is a practising physician (qualifying in 1973) and is married to fellow astronaut Bob Gibson. Starting a family following NASA selection does not seem to have hampered her assignment to a flight crew.

Jeffrey Hoffman is experienced in high energy astrophysics, having been involved with the Exosat and HEAO satellites. He worked for a time in the UK and his wife is from London. David Griggs is a former US Navy pilot who resigned in 1970 to join NASA's Johnson Space Center as a research pilot. He was involved in producing an aircraft for flying simulated Shuttle descents and became Chief of Shuttle Training Aircraft Operations in 1976.

The fourth major payload aboard *Discovery* is the first Spartan experiment - a Shuttle-Pointed Autonomous Research Tool for Astronomy. The large cargo bay allows scientists to fly equipment that would otherwise use short-duration sounding rockets (dedicated satellites are too costly). Spartan 1, carrying a set of X-ray detectors, will be released into orbit by the Shuttle's robot arm and retrieved after almost 4 days of observations. Spartan 2 with its two solar coronographs is scheduled for mission 61C in December next year (the same flight that might carry a British astronaut).



French astronaut Patrick Baudry (right) will fly aboard the Shuttle next March to operate an experiment that his backup, Jean-Loup Chretien (left), first used aboard the Soviet Salyut 7 space station in 1982. The flight was agreed upon by Presidents Reagan and Mitterand in March; the crew expects to train for six months. The "echography" experiment monitors blood flow in the body during weightlessnes. (The two French "spationauts" are seen with Soviet cosmonaut Leonid Kizim - presently aboard Salyut 7 - during their Soyuz training). *Novosti*

SATELLITES

RESCUE SATELLITES

Three further transponders for search and rescue satellites are being built by the Canadian Spar Aerospace company. The first of the original batch of three was orbited on the US NOAA-E weather satellite in March 1983 as part of the Search and Rescue Satellite Aided Tracking (Sarsat) system under development by Canada, the US and France, in cooperation with the Soviet Union.

LANDSAT 5 OPERATIONAL

Engineers at NASA's Goddard Space Flight Center have completed the checkout and activation of the Landsat 5 Earth resources satellite and turned over operational control to the National Oceanic and Atmospheric Administration on 6 April.

The 1,950 kg craft was launched from the Vandenberg Air Force Base launch complex in California on 1 March into a 705 km near-polar orbit.

NASA engineers then checked out all computer, communications, telemetry and other systems and declared the spacecraft "go" for operational use. In the first 36 days after launch engineers at Goddard acquired more than 1,013 images from the Multispectral Scanner instru-

The crew for Shuttle mission 41D, scheduled for a 20 June launch, practise fire procedures. From left are: Steven Hawley (mission specialist), Charles Walker (payload specialist), Judith Resnik (MS), Henry Hartsfield (commander), Michael Coats (pilot) and Richard Mullane (MS). The mission had the Anik communications satellite deleted because of the PAM upper stage problems. *NASA*

ment on the spacecraft and 646 from the Thematic Mapper.

Goddard experts will continue to manage and operate the Thematic Mapper portion of the ground segment, still in the experimental stage, until January 1985.

Landsat 5 was launched to replace the failing Landsat 4, which has lost 50% of its power, its direct Thematic Mapper data link to the ground and its prime command and data handling computer. NASA are now planning to launch Shuttle *Discovery* on a rescue mission in April 1986 from California to bring the $60 million satellite back to Earth or repair it in orbit. If the latter, then astronauts will have to refuel it in orbit to allow it to reach its operating altitude, higher than the Shuttle can reach.

SOLAR PANELS

ESA has asked the British Marconi company to study ways of improving the pointing accuracy of large spacecraft. The study will focus on the particular problems presented by large, flexible solar panel structures with a view to the eventual application of this research to very large telecommunications spacecraft.

Large satellites with high output powers (up to several kilowatts) need to be manoeuvred with a high degree of accuracy to ensure that their communications antennae are correctly orientated with respect to Earth. Even a tenth of a degree error in a satellite communications beam at a distance of 35,000 km could mean a serious loss of data at the ground station. Pointing accuracy is even more important for satellites with very narrow beams.

Marconi's Space Division has already embarked on an ambitious programme aimed at improving the control thruster jets (and their propellants) which react to and correct the natural drift of satellites in orbit. Earlier improvements have already led to a phenomenal increase in pointing accuracy for small, power-limited craft where the solar collecting panels are fixed to the satellite body. But large, power-hungry craft with their extended solar panels structures present a particular problem: such structures tend to bend under the impulse generated by the control thrusters. This unwanted flexing introduces further movement of the spacecraft, forcing additional correction by the thrusters and ultimately leading to further disorientation of the satellite. This could negate any improvements in thruster control and deplete the propellant tanks.

COMMUNICATIONS

NEW INMARSAT SATELLITES

Two consortia have submitted bids to the International Maritime Satellite Organisation (Inmarsat) for its second generation satellite system, due to come into service in 1988. With 40 member countries, Inmarsat provides satellite communications to the worldwide shipping and offshore industries. The bids are from: a consortium headed by British Aerospace (UK) and the Hughes Aircraft Co. (US); and a consortium headed by Marconi Space Systems (UK), Ford Aerospace and Communications Corp. (US) and Aerospatiale (France).

Inmarsat issued a request for proposals last August calling for bids for up to nine satellites, which it would either lease or purchase, to replace its first generation satellite system. The new satellites will have several times the capacity of today's satellites and will add new services aeronautical communications. The contracts are expected to be awarded next year.

For its current satellite system, Inmarsat has leased the capacity of one Marisat satellite, Marecs 1 and maritime communications subsystems on three Intelsat 5 satellites.

SOUTH AMERICAN STATION

The first coast Earth satellite station in South America began operations on 3 April. Located at Tangua in Brazil, the station is the tenth in the international maritime satellite system operated by Inmarsat.

With a 13 m dish antenna, the station transmits signals to the Marecs 1 satellite over the Atlantic at 6 HGz and receives signals at 4 GHz. Maritime satellite communications provide numerous advantages over conventional radio communications. Among them are speed, reliability, high quality and privacy as well as the provision of some services, such as high speed data transmission, which are otherwise unavailable. Conventional radio links are often plagued by ionospheric disturbances and crowded channels, making contact difficult and sometimes impossible.

PAM DELAYS

The launch of the Hughes company Galaxy communications satellite on 24 May is being delayed at least two months, it was announced in late March, because of uncertainty with the PAM upper stage. Two Payload Assist Modules failed during Shuttle mission 41B in early February but the cause was still uncertain at the time of the decision.

The Galaxy/PAM combination was to have been orbited by a Delta rocket from Canaveral. It was not known at the time if the PAM due to be flown on Shuttle mission 41D in June will be affected [now confirmed—*Ed*].

OTHER NEWS

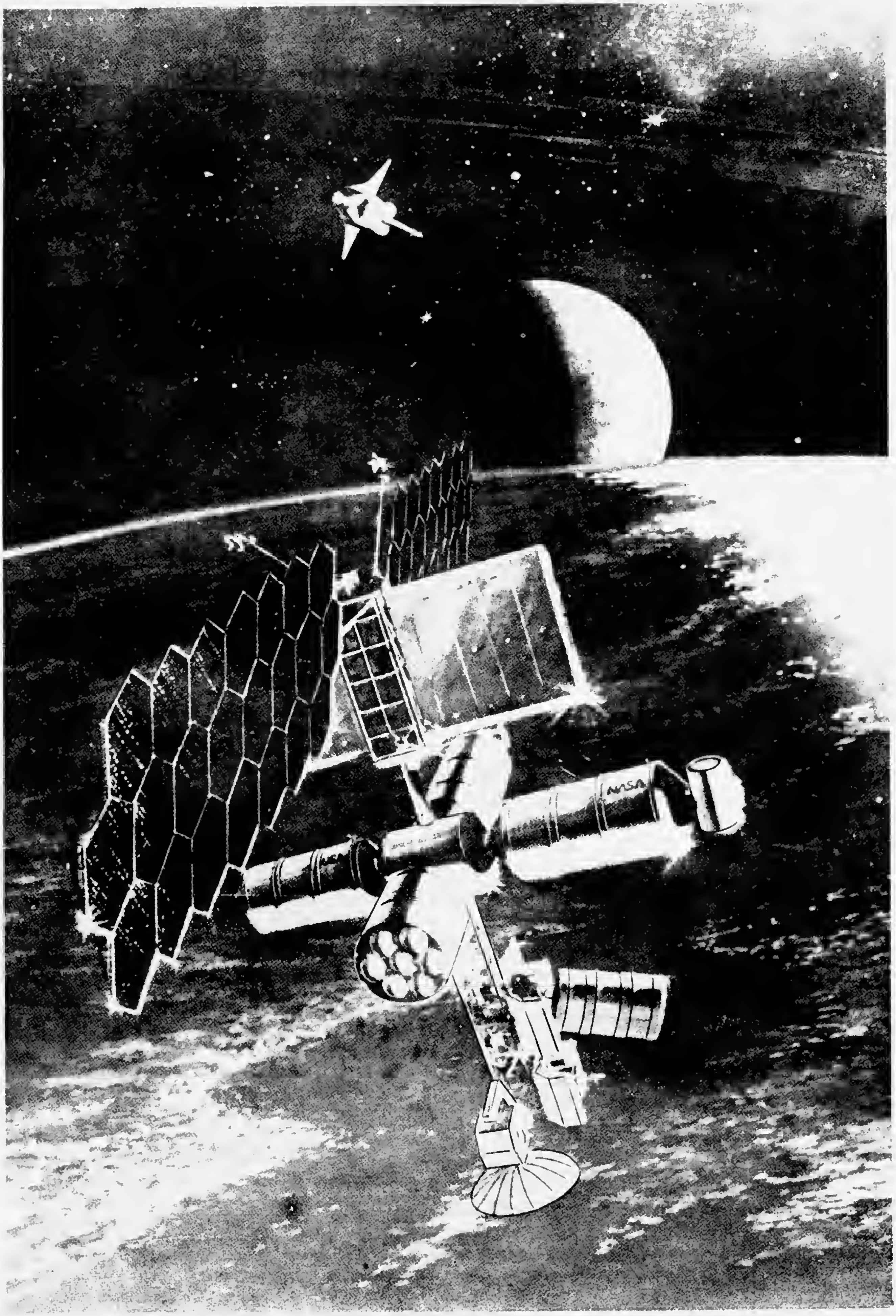
ACTING SPACE CHIEF

Jesse Moore has been appointed Acting Associate Administrator for Space Flight for NASA, succeeding Lt. Gen. James Abrahamson who became Director of Strategic Defense in the Department of Defense on 15 April.

Moore, who had been Abrahamson's Deputy, came to NASA Headquarters in 1978 as the Deputy Director of the Solar Terrestrial Division in the Office of Space Science. He was the Director of the Spacelab Flight Division until December 1981, at which time he assumed the position of Director, Earth and Planetary Exploration Division in the Office of Space Science and Applications, where he remained until being appointed in February 1983 to the position of Deputy Associate Administrator for Space Flight.

Facing page: a possible configuration for the US Space Station from the TRW company. Note the use of European Spacelab modules and pallets. NASA has awarded the McDonnell Douglas company a contract to study the space and ground-based data system needed to operate a permanent manned space station.

The data system will be a key part of the overall space station programme, covering all the computers, displays and programmed instructions to run the computers needed to operate the station's vital systems; to support on-board experiments and commercial missions and to transmit data between the station, nearby free-flying platforms


NASA

MILESTONES

March 1984

28 The US House of Representatives approves an authorization bill to allow NASA almost $7500 million for a Space Station.

30 Attempt by Starstruck Inc. of California to launch its prototype Dolphin suborbital rocket from the sea off San Diego is aborted when sea water leaks into an electrical connection.

April 1984

2 Soyuz T-11, with cosmonauts Yuri Malyshev (commander), Gennady Strekalov and Rakesh Sharma (India), is launched at 17.09 Moscow Time, docking with Salyut 7/Soyuz T-10 at 18.31 MT the next day. They return in Soyuz T-10, landing at 14.50 MT on the 11th, 46 km east of Arkalyk. Salyut 7 occupants Kizim, Solovyov and Atkov continue their long-duration flight.

2 French 'spationaut' Patrick Baudry will fly on the Shuttle next March (see p.63 of February's *Spaceflight*). Baudry was backup to Jean Loup Chretien in the Soviet-French mission of 1982; their rôles are now reversed.

6 Shuttle mission 41C is launched. The LDEF is released on 7th; George Nelson fails to capture Solar Max on 8th; Solar Max is snared by the robot arm on 10th; Nelson and Van Hoften repair the satellite on 11th; it is released on 12th. *Challenger* lands in California on 12th instead of Florida because of cloud at KSC.

8 China launches another satellite, the second from its new launch site. The test communications satellite reaches geosynchronous orbit on the 10th.

9 The Anik communications satellite intended for launch aboard Shuttle mission 41D in June will be held on the ground until the cause of the two PAM upper stage failures in February is found. US Navy Navstar and Hughes' Galaxy satellite are also being delayed. NASA are formulating plans to rescue the Palapa satellite lost in February.

9 Neil Hutchinson is named as Space Station Manager at the NASA Johnson Space Center.

14 A Titan 34D is launched from Cape Canaveral, such vehicles usually carry missile early warning or military communications satellites. A 34D launch was also made on 30 Jan.

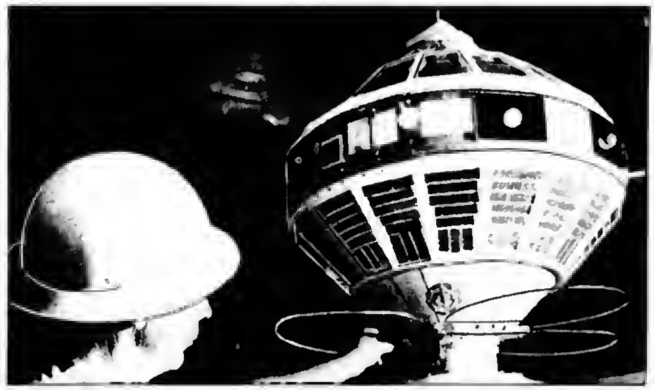
15 Progress 20 is launched at 12.13 Moscow Time and docks with Salyut 7 on the 17th at 13.22 MT carrying fuel and supplies.

23 Salyut 7 cosmonauts Kizim and Solovyov make a spacewalk in preparation for later maintenance work. Oleg Atkov remains inside the station. Further walks were made on 26th and 29th.

23 It seems likely that Shuttle mission 41H, scheduled for 28 September, will be cancelled because the Inertial Upper Stage has still not be cleared for flight.

DO YOU KNOW?

Can you identify this early US satellite, part of a lengthy series?



Answer: this is the Explorer 7 satellite, launched by a Juno II rocket on 13 October 1959. With a weight of 92 lb, it was known as the "kitchen sink" satellite because of the variety - for those days - of experiments carried to study radiation and micrometeoroids. The Juno II launcher was modified from the Jupiter missile and used on only 10 occasions, the first two for the Pioneer 3 and 4 lunar probes.

DO YOU REMEMBER?

25 Years Ago...

25 June 1959. Discoverer 4, launched by Thor/Agena A from California fails to reach orbit due to insufficient second stage velocity.

7 August 1959. Explorer 6 is launched by Thor-Able from Cape Canaveral to study radiation in near-Earth space. It also took the first photograph of Earth from space.

20 Years Ago...

10 July 1964. A Soviet A-1 launcher places Elektron 3 and 4 in Earth orbit. The two satellites monitored the Van Allen radiation belts and investigated the composition of Earth's upper atmosphere.

31 July 1964. Ranger 7 crashes on the Moon as planned after returning over 4,000 photographs of the lunar surface.

15 Years Ago...

2 July 1969. The second ELDO attempt to orbit a Europa from the Woomera launch site in Australia proves unsuccessful. The third stage failed to ignite.

20 July 1969. "Houston. Tranquility Base here. The Eagle has landed." Apollo 11 commander Neil Armstrong reports the first manned lunar landing.

10 Years Ago...

3 July 1974. Soyuz 14 with cosmonauts Popovich and Artyukhin aboard is launched from Tyuratam on a mission to the Salyut 3 space station.

1 August 1974. America's first man in space, Alan Shepard, retires from NASA and the US Navy.

5 Years Ago...

11 July 1979. The Skylab space station reenters Earth's atmosphere over the Indian Ocean. Debris from the station fell over 6,000 km of ocean with some denser pieces reaching S.W. Australia.

15 August 1979. Salyut 6 cosmonauts Lyakhov and Ryumin perform an 83 min EVA during which a radio-telescope dish is disconnected from the station.

K.T. Wilson

NEWS FROM THE CAPE

The Latest Developments from Cape Canaveral in Florida

By Gordon L. Harris

FUTURE DEMANDS

KSC Director Richard Smith has told employees to expect changes in the centre's organisation. "Increased efficiency in management of Shuttle processing and base operations contracts, additional support of Vandenberg Air Force Base operations (expected to launch Shuttles from late 1985), demands of the STS-Centaur schedule and the space station will have a bearing on the KSC organisational structure," he said.

Smith pointed out that KSC has greater engineering expertise in some specialised areas than other NASA centres, which will be important to space station development. "We will need to provide increasing support for design of facilities and ground support equipment," he added. Smith believes his centre may have to accept more responsibility for Shuttle mission functions currently performed by the Johnson Space Center to relieve JSC so that it can concentrate on the space station.

SATELLITE REPAIR

NASA has been studying the possibility of capturing the Palapa B2 satellite in October. The rescue depends upon negotiations between Indonesia and its insurance companies on costs associated with recovery, repair and re-launch of the communications spacecraft. Lt. Gen. James Abrahamson, who recently left NASA to head the US space defense research project, said the mission is technically feasible.

Estimated to be worth $75 million, the satellite was released from *Challenger* during mission 41B in February but failed to achieve geostationary orbit because its boost stage, the McDonnell Douglas PAM, malfunctioned. A second satellite owned by Western Union experienced a similar failure. Westar 6, valued at $100 million, was also insured.

Neither is equipped with a grappling device such as Solar Max carries. Instead, an astronaut would attempt to connect with a 10 cm graphite spike protruding from the top of the satelite.

MAIN ENGINES

Shuttle main engines, designed to fly 55 missions without overhaul, are wearing so fast that repairs are needed after every mission, the *Miami Herald* reported. The newspaper quoted Walter Dankhoff, director of NASA's engine programme, as saying, "The engines have performed successfully every time they have flown but we are just not getting the life out of them we hoped for." There is talk of complete re-design of major components possibly costing $1000 million and requiring 10 years work.

The *Herald* cited this record:

Columbia, November 1981 (STS-2): fuel pre-burner and engine nozzle repaired, main fuel valve replaced.

Columbia, March 1982 (STS-3): high pressure oxidizer pump removed and repaired.

Columbia, July 1982 (STS-4): two high pressure fuel pumps, failed engine controller and low pressure oxidizer replaced.

Columbia, November 1982 (STS-5): high pressure fuel pump and main fuel valve replaced, engine nozzles repaired.

Challenger, April 1983 (STS-6): all three engines removed, repaired or replaced due to leakage in hydrogen lines. One engine nozzle replaced.

Challenger, June 1983 (STS-7): high pressure fuel pumps removed, two repaired, one replaced.

Challenger, August 1983 (STS-8): cracked high pressure fuel pump repaired.

Columbia, December 1983 (STS-9): low pressure fuel pump replaced, three engine controllers replaced.

Challenger, February 1984 (41B): high pressure fuel pump removed, one engine controller replaced, fuel pre-burner and nozzle repaired, one engine replaced due to faulty hydrogen line.

NASA asked Dr. Michael Billett of Pennsylvania State University to review the situation. After 18 months he found that "Rocketdyne [the manufacturers] simply did not anticipate all the problems they encountered." He said one cause is cavitation, the erosion that occurs when a moving fluid strikes a metal surface. The space agency has also suggested an evaluation by Rocketdyne's competitors: Aerojet Tech Systems and Pratt and Whitney.

A DEER SOLUTION

Historic Cape Canaveral, managed by the US Air Force for the Defense Department as a joint proving ground for military missiles and launches of NASA's Delta and Centaur expendable boosters, has been confronted with an old problem given a novel twist by the State of Florida. The problem: a herd of 1,000 white tailed deer inhabiting the scrub thickets of the 18,000 acres reservation.

During the last two years deer were involved in collisions with government and privately owned employee vehicles, causing $37,000 damage. To reduce the hazard on 170 km of improved roads the Air Force wants to cull 200-250 animals as the military have done in the past.

From 1972 to 1980 the State Game and Fresh Water Fish Commission trapped about 100 deer annually and transplanted the animals to State or Federal parks and forests. That was ended because of the cost, estimated at $200 per deer, and the increasing herds within hunting areas elsewhere.

The roving animals are hazardous not only to motor vehicles but also to aircraft landing and departing from a 3 km runway known as the "Skid Strip," where Gemini astronauts flew in after splashdown in the Atlantic and where huge cargo 'planes take off.

EN ROUTE TO THE GIANT PLANET

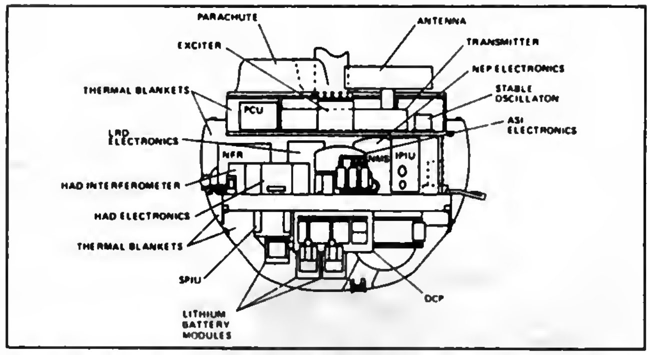
The Galileo Jupiter probe, which will make the first entry into the atmosphere of an outer planet, has been completed. Jupiter entry is by far the most difficult in the Solar System because of the planet's high gravity. The probe will descend through Jupiter's turbulent and brilliantly-coloured cloud layers and penetrate 600 km into the hot, dense atmosphere below.

Introduction

The 1.5 m diameter craft, almost half of which is a heat shield, will enter the atmosphere at 185,000 kph - fast enough to cross the Atlantic in 90 seconds! The maximum deceleration will be 350 times that of Earth's gravity. After entry and separation of the heat shield, the probe's parachute-borne Descent Module will study Jupiter's three main cloud layers, encountering hurricane winds of up to 350 kph and perhaps heavy rain at the base of the expected water clouds. Seven instruments will provide the first direct information on these surroundings.

Completion of Craft

Engineers and officials from NASA and the Hughes Aircraft company gave the new craft their final approval at a "pre-ship review" on 9 February at the company's plant in California. The probe then went to the Jet Propulsion Laboratory in Pasadena for integration with



Internal errengement of the Descent Module. *Key:*- SPIU: system power interface unit; LRD: lightning end radio emissions detector; NMS: neutrel mess spectrometer; DCP: dete and commend processor; PCU: pyro-control unit; ASI: atmosphere structure instrument; NEP: nephelometer; HAD: helium ebundance detector; NFR: net flux radiometer.

the Galileo Orbiter which will carry it until five months before Jupiter entry.

The mission will conduct a comprehensive exploration of the Jovian system with the two craft (see *Spaceflight's* 'Space at JPL' section over the past year for recent reports). The probe's data will be radioed to the Orbiter, flying a parallel course 190,000 km above, for relay to Earth. The Orbiter itself will fly past the large moons (the 'Galilean' moons, so-called because Galileo was able to see them through his primitive telescope) some 100 times closer than the Voyager probes. Being in orbit around Jupiter, it well also be able to do it repeatedly.

During the 20-month mission after arrival, the Orbiter will complete 11 circuits of Jupiter, returning 50,000 high-resolution images of the planet and its retinue. Each orbit will produce a close flyby of at least one Galilean satellite - Io, Europa, Ganymede or Callisto.

The Flight Plan

The 2550 kg Galileo orbiter/probe craft will be carried up to low Earth orbit by the Space Shuttle in May 1986. It will then be launched to Jupiter by the first of the modified "wide body" Centaur vehicles, which have 50% more fuel capacity than previous Centaurs. (This new version is the only vehicle capable of sending the combination across the 800,000,000 km to the planet).

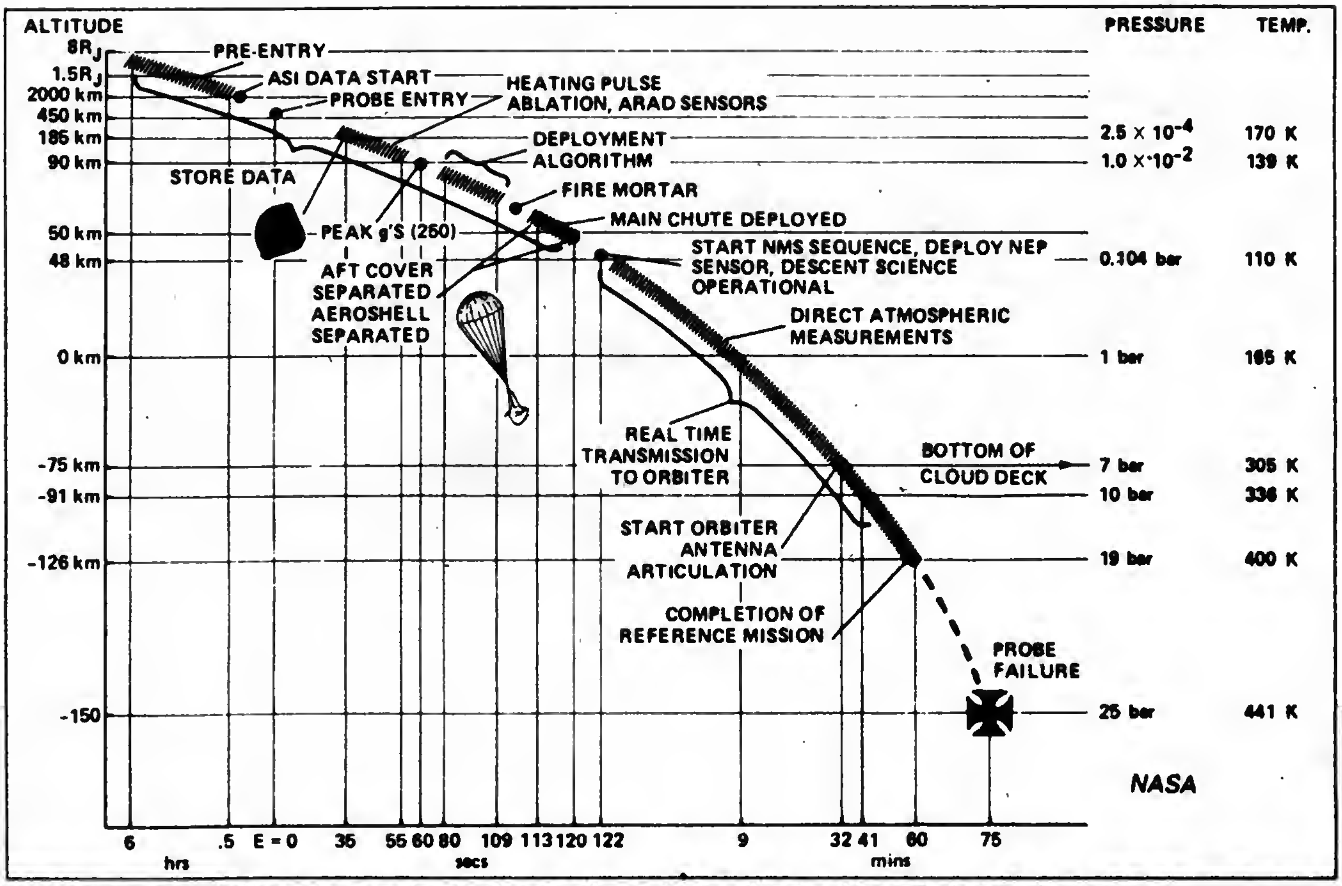
The probe will separate five months before planet-arrival and follow its own trajectory to atmospheric entry on 25 August 1988. After entry, the probe's job will be completed in 60 to 75 minutes, when the Orbiter moves out of range and conditions in the deep atmosphere exceed the probe's design limits. The Orbiter will then position itself for a close pass by the moon Io, and Jupiter orbit insertion.

The probe's tasks are to determine the atmoshere's:

1. chemical composition, including minor constituents, isotopic ratios and the hydrogen/helium ratio;
2. density profile from initial detection to mission end;
3. temperature and pressure profiles.

The other science objectives are:

4. to find the location and structure of Jupiter's clouds;
5. determine the atmosphere's radiative energy balance;
6. investigate Jovian lightning.

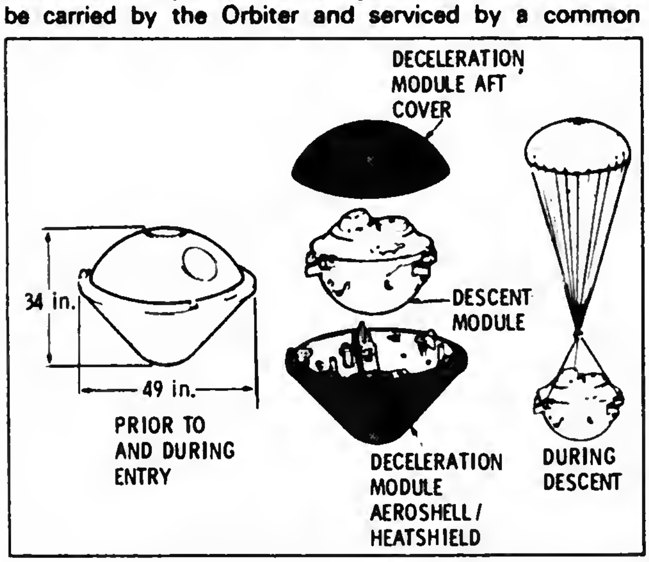


Descent profile for the Galileo probe. R_J on the altitude scale refers to Jupiter's diameter; 1 bar is Earth atmospheric pressure.

ment from several sensors in the Probe Deceleration Module or from the seven instruments aboard the parachute-borne Descent Module. Measurements should be possible down to at least 20 bars pressure (20 times Earth's sea-level pressure) before end of communications. Maximum possible depth before loss of radio contact is 25 bars pressure, and 25 km deeper than the planned mission. At that stage, the Orbiter must turn away for its encounter with Io.

Other probe work includes measurement of Jupiter's numerous radio emissions and observing trapped high-energy particles down to the atmosphere top - far closer than measured by Pioneer 11's 41,000 km closest approach. It will also measure wind speeds by Doppler radio measurements made aboard the Orbiter.

The probe's mission has four phases: launch, cruise, coast and entry-descent. During launch and cruise it will be carried by the Orbiter and serviced by a common



umbilical. It will be dormant during cruise except for periodic checkouts of systems and instruments every six months. During this period, the parent craft will provide it with power, commands, data transmission and some thermal control.

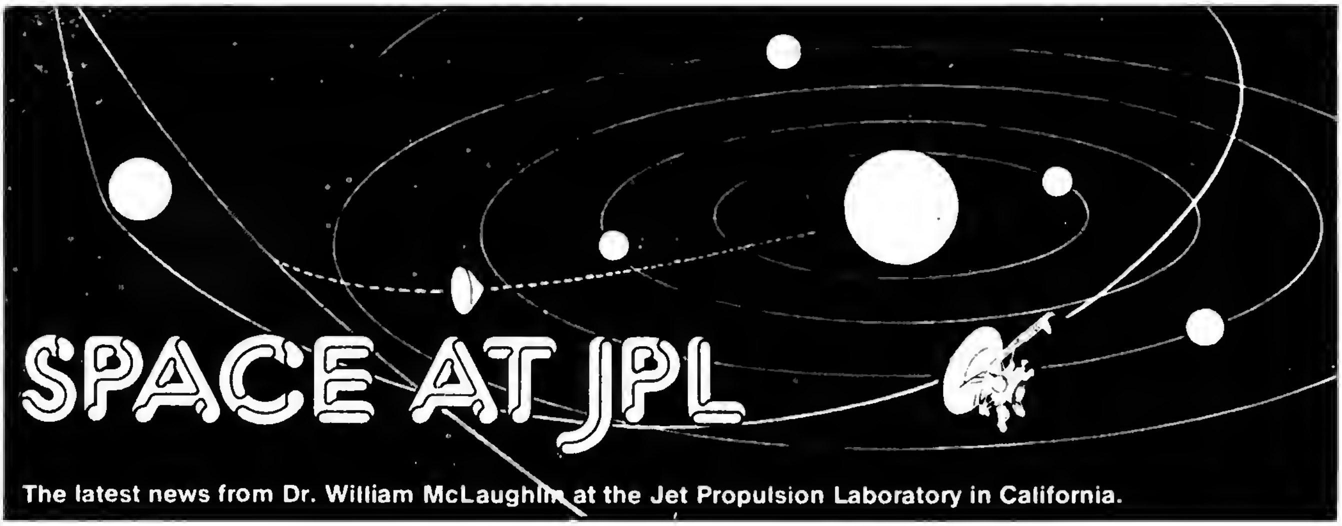
Five months before planet arrival in late March 1988, the Orbiter will spin up and aim the probe on its entry trajectory. The spin-stabilised probe will separate and fly to Jupiter. Six hours before entry it will be travelling at 65,000 kph. At that point, its command unit will signal "wake up" to begin collecting data.

From there it will accelerate steadily until it enters the atmosphere at 185,000 kph, causing the incandescent shock front ahead of its heat shield to be as bright as the Sun.

Peak acceleration forces will come about two minutes after entry. Two minutes after that a drogue parachute will deploy and pull the aft cover away to allow the main chute to open while the Deceleration Module with its massive heat shield falls away. From there on, the Descent Module with its seven instruments will sink towards the brilliant cloud tops.

The probe's total weight is 331 kg; the Deceleration Module with the carbon phenolic heat shield (itself 145 kg) and aft cover is 214 kg; and the Descent Module is 118 kg. The Descent Module's scientific instruments account for 28 kg.

The power comes from a rapid discharge 34 volt lithium battery, which must remain dormant for more than two years for the trip to Jupiter. The Probe Relay Radio aboard the Orbiter will have two redundant receivers to process science data, plus radio science and engineering data for transmission to the Orbiter communications system. The unit must automatically acquire the probe signal 160,000 km below within 50 seconds, with a success probability of 0.995; it must reacquire immediately if the signal is lost.



VOYAGING TO NEPTUNE

Neptune, the planet of Adams and Le Verrier, is currently the outermost known planet in the Solar System and will retain that extreme position until early in the next century when Pluto again takes over. If all goes well, the Voyager 2 spacecraft will make its closest approach to Neptune at about 23 hours 12 minutes GMT on 24 August 1989, passing within 7,500 km of the north-polar cloudtops.

Although most of the attention of the Voyager project is devoted to the upcoming encounter of Voyager 2 with Uranus in January 1986, some planning for Neptune is also being conducted. The Voyager Uranus/Interstellar Mission (VUIM) is funded through to the end of March 1986. Then, assuming government approval, the Voyager Neptune/Interstellar Mission (VNIM) will extend from 1 April 1986 to 31 December 1989 when the last views of Neptune will have been recorded and both Voyager spacecraft are proceeding starward (by 1998 the rapidly moving Voyager 1 will have outdistanced Pioneer 10, now the most distant spacecraft, and lead the fleet of two Voyagers and two Pioneers in their escape from the Solar System).

The scientific objectives of VNIM include studies of the planet, satellites (two are known: Triton and Nereid, and a third is suspected to exist), and detection and investigation of rings or any small satellites that might be present. For Neptune itself, these studies will examine magnetic field properties; measure the atmospheric temperature profile; determine the atmospheric composition and structure; measure the planetary rotation period, mass and 'J_2 zonal harmonic' (a measure of the gravitational field); and estimate planetary heat balance. Satellite radii will be defined and it should be possible to determine the mass of Triton to better than 5%. If Triton has an atmosphere its properties will be analysed by instruments and an occultation experiment; the trajectory also results in an occultation of the spacecraft by Neptune as seen from Earth. Occultations are a well-tested means of studying atmospheric properties by studying the effects of the atmosphere on the craft's continuous radio signal as it passes behind a planet or satellite.

The sensitivity of the Voyager imaging system is adequate to record Neptune's features. Light levels at Neptune are ten times lower than at Saturn but, in compensation, the wide-angle camera is ten times more sensitive than the narrow-angle camera, which was certainly effective for imaging at Saturn.

At the great distance of Neptune it is important to have as much ground support by large radio telescopes as possible. Hence, the project hopes to have available three 70 m antennae of the Deep Space Network (DSN) (upgraded from their present 64 m diameter); six 34 m DSN antennae; two 64 m antennae from the Australian and Japanese governments; part of the Very Large Array in New Mexico; and the capability to array together several of these individual instruments (see "Space at JPL" in the March issue). If these plans can be implemented, up to 21.6 kilobits per second of data will be returned from Neptune, less than Voyager's 115.2 kilobits per second at Jupiter but sufficient to obtain up to 300 images per day plus other scientific data.

Barring unexpected problems, Voyager 2 should have sufficient propellant (some 66 kg of hydrazine remains from its original stock of 103 kg) and vitality in its subsystems to complete the survey of the four gas giants which began ten years earlier with Voyager 1 at Jupiter.

ASSEMBLING AND TESTING GALILEO

The Galileo spacecraft, consisting of an orbiter and an atmospheric probe, is scheduled for launch in May 1986 to conduct a detailed study of the Jovian system. The process of integrating the orbiter and probe into one system and testing the assembled product is now underway at JPL.

The spacecraft subsystems e.g. radio, onboard computers, power and instruments, are mated to the bus (main structure) and then tested for their ability to interface properly. Before delivery for integration and testing, the individual subsystems had been tested but, on occasion, problems are encountered in this subsequent system testing and some reworking of the subsystem is necessary. In many ways the integration and testing of flight hardware parallels a similar procedure for the verification of the functioning of large ground-software systems. Here, previously tested computer programs are brought together and checked for their ability to operate harmoniously. The similarity is not complete, though; ground-software testing does not risk blowing fuses or compromising flight-quality parts as hardware testing does.

After assembly, integration and functional verification, the spacecraft will be put through a series of environmental tests designed to prove its capability to withstand the demands of launch and subsequent mission operations.

This summer and autumn will see Galileo undergoing vibration testing on a "shake table" and immersion in JPL's 8 m space simulator. The simulator allows "solar/thermal/vac testing," as it is commonly referred to, wherein the effects of the Sun and the near vacuum of space are measured. The simulator features a broad beam of light whose rays are parallel, like the Sun, and whose spectral characteristics are closely matched to those of the real Sun. The chamber of the simulator can be pumped down to pressures of 10^{-6} or 10^{-7} Earth atmospheres, yielding a satisfactory approximation to the vacuum of space.

The craft will have been assembled and tested well before launch. The period before shipping it to the Cape will be used for running the completed spacecraft in an effort to circumvent the "infant-mortality" syndrome. This operation is designed to reduce the risk of failure, common to new machinery, when the vehicle is in space and beyond human repair. Much of this break-in activity will be conducted with the spacecraft unattended, with monitoring by computer.

Galileo, unlike Voyager or Viking, is being prepared with a mind to the so-called "ship and shoot" procedure. This concept calls for the spacecraft to be brought to a state of readiness very near to that required for launch, before being sent from JPL to KSC. Of course, certain actions, like loading propellant onboard, still need to be done at the launch site. The procedure used for previous JPL missions was to ship the spacecraft to the launch site and conduct another round of system testing, and perhaps modifications, in the field.

Project Galileo is managed by JPL for NASA with John Casani as project manager. The Ames Research Center is responsible for the probe. Thanks are due to Richard F. Collins, manager of the Laboratory's Project Test and Operations Section, for discussing the assembly and test of the spacecraft and for a tour through the Spacecraft Assembly Facility (SAF) to see Galileo being fashioned into a sleek robot for service in the middle Solar System.

GALILEO FLIGHT PATH

Just as a superb network of roads facilitated the movement of men and material throughout the Roman Empire, a carefully constructed flight path will move the Galileo spacecraft through the domain of the Solar System, from Earth to Jupiter.

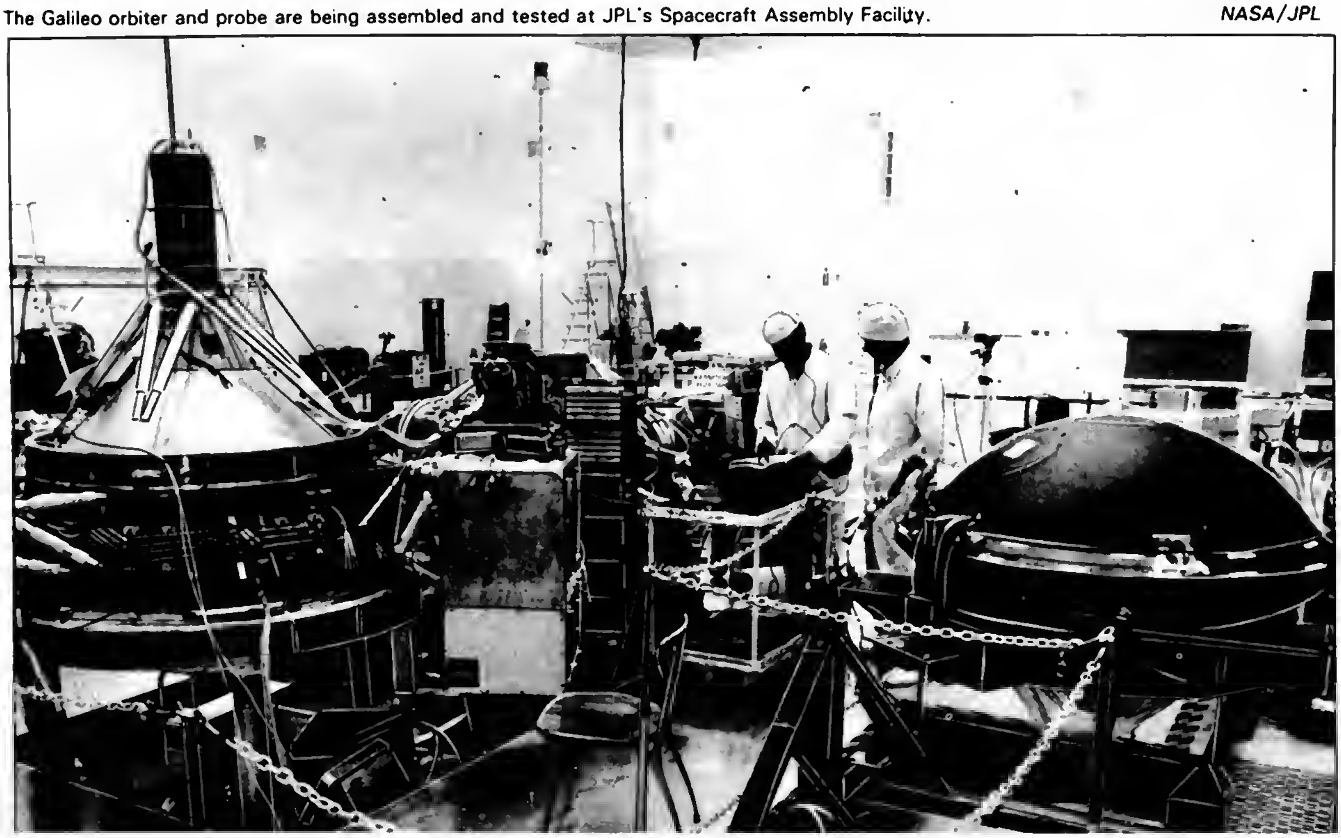
To continue the metaphor of the roads: some paths are free and others require payment of a "toll." However, the transaction does not involve the Roman denarius or tollbooths but rather the expenditure of propellant at selected points. It is customary to measure this expenditure in terms of ΔV (delta-vee), or change in velocity, in units of metres per second (m/s). Although the rate of exchange is not constant, it is of the order of 2 m/s per kilogramme of propellant.

The IRAS spacecraft, for example, was toll-free once it achieved Earth orbit: no expenditure of ΔV. The Galileo spacecraft is not so fortunate; its far more complex flight path will require numerous kicks from the motor to keep it on the proper course. Using ΔV as a measure of toll payment at various junctions, let us follow Galileo in interplanetary space as it travels from Earth to Jupiter.

There are two fundamental ways in which ΔV is employed in a spacecraft manoeuvre: to make a basic change in the flight path, and to correct the flight path to bring it back to planned: small errors in execution of a previous manoeuvre (ΔV expenditure) or unexpected perturbations of the craft can occasion this latter application, which is called a "statistical manoeuvre." The former type is termed a "deterministic manoeuvre." Statistical manoeuvres can be likened to keeping the chariot on the cobblestones with a few pence handed over to the local authorities as one travels along a prescribed path. On the other hand, the deterministic manoeuvre usually represents a major investment to switch from one road to another.

After launch from a Shuttle/Centaur G' combination, a small statistical ΔV of a few m/s is applied to correct

The Galileo orbiter and probe are being assembled and tested at JPL's Spacecraft Assembly Facility. *NASA/JPL*



any launch inaccuracies. Then, about 8 months after launch, a very large 200 m/s deterministic manoeuvre changes the plane in which the spacecraft is travelling by about one degree so that Galileo will encounter Jupiter. Theoretically, this "plane change" could be avoided by expending somewhat more ΔV with the Centaur, but the masive Galileo spacecraft (2250 kg; of which 932 kg is propellent) exceeds the Centaur's capacity for a single-plane route to Jupiter.

Trajectory designers at JPL put considerable effort into selecting the exact form of this plane-change manoeuvre in order to minimise the required ΔV. A new computer program, PLATO (Planetary Trajectory Optimization), was developed specially for this task. The Galileo project seems to have a penchant for classical allusion since programs ADAM, SATAN and CAIN are employed in the navigation process.

Several months before arrival at Jupiter, the flight path is adjusted to aim the vehicle at Jupiter so that when the atmospheric probe is released it will encounter the planet at the desired lattitude, longitude and flight path angle. After release of the probe, 150 days before Jupiter encounter, an orbiter deflection manoeuvre of approximately 60 m/s is required so that the orbiter does not follow the probe into the Jovian atmosphere! Not only must the planet be missed but the orbiter must be targetted to overfly the site of the probe's entry into the atmosphere of Jupiter so as to relay data from the probe back to Earth.

Moreover, this deflection manoeuvre establishes a trajectory that carries the orbiter past the satellite Io, as close as 1000 km, for the dual purposes of scientific investigation and acquisition of a gravity assist. The gravity assist, equivalent to 150 m/s of ΔV, is supplemented by a deterministic manoeuvre of 600 to 700 m/s and, together, the two events transfer Galileo from its interplanetary trajectory to an orbit about Jupiter.

It is August 1988. Galileo is now ready to begin its 20 month study of the Jovian system. The next edition of "Space at JPL" will follow the orbiter as it plays an intricate game of cosmic billiards with the Galilean satellites. (Yes, a new metaphor is called for.)

AN ARCTIC POLESITTER

The advanced mission concept for this month's review incorporates an idea whose roots go back into the 19th. century: a spacecraft that hovers above the polar region.

In principle, by expending enough propulsive energy one can suspend a stationary satellite above any point on Earth at any altitude. However, because of practical limitations on current technology, only equatorially stationary satellites have been employed, primarily for communication purposes as per Arthur C. Clarke's 1945 suggestion. At the "geosynchronous altitude" of approximately 36,000 km these equatorial satellites have, by the laws of celestial mechanics, a period of revolution that matches the rotation rate of the Earth; they thus appear to be stationary to an observer on Earth.

It is clear that if a spacecraft could be maintained above either pole of the Earth it, too, would function as a geostationary satellite. Unlike geosynchronous satellites, in order to preserve this particular geometric configuration it would be necessary to apply a more or less continuous thrust to counteract the gravitational tug of the Earth and perturbing forces from the Moon and Sun.

The German mathematician and science fiction writer Kurd Lasswitz described such a polesitter in his 1897 utopian novel *Auf zwei Planeten* (available in a 1971 edition in English, abridged: *Two Planets*, Southern Illinois University Press). The two planets contained in the title of this work are Earth and Mars, and the polesitter serves as a transport station for the Martians in their goings to and from Earth. Incidentally, this novel has had an influ-

Starting in August 1988, Galileo will explore Jupiter and its four Galilean satellites. In this depiction by Graphic Films Corp. for NASA/JPL, a volcano is erupting on the satellite Io.

ence on German astronautical thought, as pointed out by Arthur C. Clarke in *The Making of a Moon*. In the English edition of Lasswitz's novel Mark Hillegas concurs: "In the history of man's speculation and dreams about space flight, *Auf zwei Planeten* has a secure and important place."

Lasswitz's polesitter was able to maintain itself at an altitude of only one Earth radius above the north pole by converting sunlight into some sort of electromagnetic suspension process. Since our technology is not yet as advanced as that of Victorian-era Martians, a present-day polesitter would need to be located many Earth radii above the pole in order to be able to counteract gravity with propulsion for reasonable periods of time. Johnie Driver of JPL has studied the requirements of a polesitter; he finds that using solar or nuclear electric propulsion for continuous thrusting a 1000 kg spacecraft could be maintained above the pole at a distance of a hundred or more Earth radii. Although no such project is currently funded or being studied at the Laboratory, it does possess some attractive attributes. Driver envisages the polesitter as being employed to obtain continuous imaging of the polar regions at a resolution of 3 to 100 km in the optical and infrared regions of the spectrum.

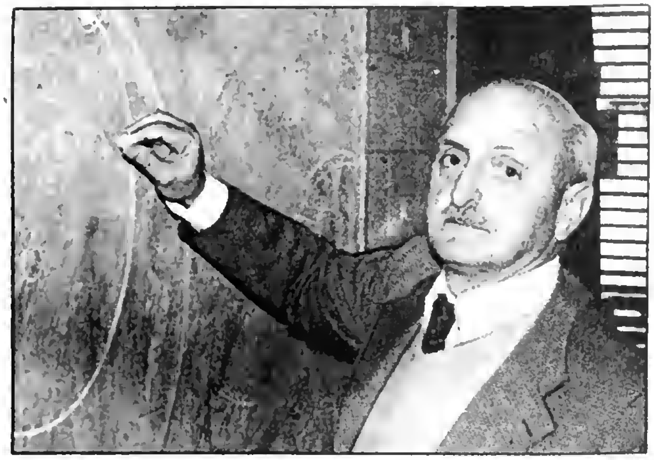
Driver proposes a solar electric propulsion system with 30 cm mercury ion bombardment thrusters. He finds that this system can keep a 1000 kg mass for one year at a distance of 173 Earth radii (about 3 lunar distances). With a modest power reserve all of the thrusters could be shut off for several days and then restarted without the spaccraft falling below the safe-recovery region. The pointing direction for the thrusters would need to be varied with time because of the changing positions of Sun and Moon. If a constant altitude were required, the magnitude of the thrust vector would also have to be adjusted with time. The numerical conclusions are probably somewhat pessimistic since they are based upon ion propulsion technology as it existed in 1977. For further details see "Analysis for an Arctic Polesitter" in the *Journal of Spacecraft and Rockets* **17**, May-June 1980, pp. 263-269.

An extension of Driver's Earth-polesitter study would be to examine the merits of positioning a spacecraft ten million or so kilometres above a pole of Saturn so as to study the system of rings and monitor certain time-dependent phenomena (not all phenomena would be accessible to such a satellite; the so-called spokes in Saturn's rings are probably better imaged from lower latitudes).

A Saturn ring surveillance (SRS) mission of this type bears some generic resemblances to the Saturn ring rendezvous (SRR) mission described in the April 1983 edition of "Space at JPL." Both would use continuous-thrusting techniques to place their spacecraft in a non-Keplerian orbit for the purpose of studying the entire system of rings. The SRR mission would conduct a sequence of measurements of a local nature at very close range and synthesise them into a global picture, while the SRS mission would obtain immediate and continuous global information at the expense of the detail of the SRR mission.

IN MEMORIAM

The noted space scientist Dr. Giuseppe Colombo died in Padua, Italy on 20 February at the age of 63. Colombo had been a Distinguished Visiting Scientist at JPL and for many years had commuted between Pasadena, Cambridge (Massachusetts) and Padua in connection with his numerous space-related activities.



Space scientist Dr. Giuseppe Colombo died in Padua, Italy on 20 February at the age of 63. He was an international authority on celestial mechanics and space structures.

Colombo was born in Padua in 1920. He graduated from the University of Pisa in 1943 with a degree in mathematics and obtained his Ph.D. in mathematics from the University of Padua in 1951.

Throughout his career he held several professional appointments at the Italian Universities of Catania, Modena, Genoa, Pisa and Padua in the fields of mechanics and mathematical physics. In 1961 he was appointed Visiting Celestial Mechanician at the Smithsonian Astrophysical Observatory and, in 1962, a Visiting Research Associate at the Harvard College Observatory.

In 1964 Colombo was appointed as the Director, Institute of Applied Mechanics, University of Padua, and then in 1974 to the post of Professor of Celestial Mechanics, Scuola Normale Superiore, Pisa. In the United States, in addition to being a Distinguished Visiting Scientist at JPL, he was a Visiting Associate in Planetary Science at Caltech in 1978, Jerome Clarke Hunsaker Visiting Professor of Aeronautics and Astronautics at MIT in 1980 and Sherman Fairchild Distinguished Scholar at Caltech in 1982.

Colombo received many international awards and honours, including NASA's Medal for Outstanding Scientific Achievement in 1983. He was a member of several learned societies such as the Academies of Science of Padua, Turin, Venice and Rome and the American Academy of Arts and Sciences.

Within the JPL community probably his best-known achievement was with regard to trajectory selection for the Mariner 10 mission to Venus and Mercury. It was Colombo who, in 1970, first suggested that the spacecraft's trajectory could be shaped so as to allow an encounter with Mercury more than once; in fact, Mariner 10 wound up taking data at Mercury three times before it ran out of attitude control gas.

As described in the December 1983 "Space at JPL," he was also a prime mover in the Tethered Satellite System, a cooperative programme between Italy and the US to study the Earth's atmosphere with a tethered probe to be deployed as far as 100 km below the Shuttle in 1987.

My contact with Colombo came through using his expertise in celestial mechanics. Having drawn extensively upon his published papers on the structure of Saturn's rings, we finally met in person after he had refereed a paper I published on the subject in *MNRAS* in 1977. My impressions of the man have been confirmed by others who worked with him; he combined intellectual vigour with a gentle heart.

GLOWING IN THE DARK

By John Bird

Despite years of preparation and millions of dollars, even the most meticulously-planned projects can produce unexpected surprises. The "glowing Shuttle" phenomenon, described below, is an example.

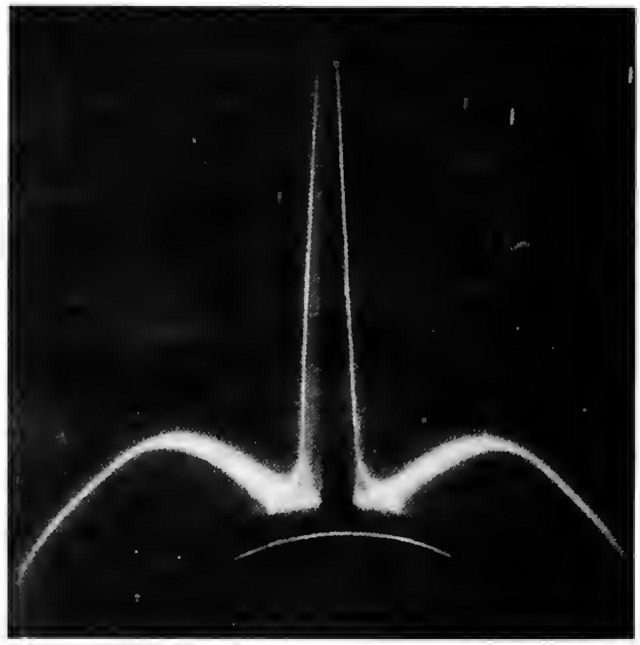
Introduction

Since the discovery of a mysterious glow on the Shuttle during STS-3 mission in March 1982, scientists have been working to understand the effect. Surfaces facing into the direction of motion (or 'velocity vector') were found during orbital night to be covered with a faintly glowing thin orange layer visible to the naked eye. The effect is not just a scientific curiosity but is of great importance to some of the experiments and satellites planned for the cargo bay. For example, instruments designed to observe faint stars will have a more restricted field of view since they will not be able to look over the Orbiter's surfaces.

A similar effect was found on the Atmosphere Explorer-C satellite, produced from the thin atmosphere colliding with the satellite moving at 8 km/s. As the altitude increased, the effect decreased, suggesting a dependence on air density.

The STS-3 crew of Jack Lousma and Gordon Fullerton unknowingly took pictures of the glow while they were photographing electron beams from the Vehicle Charging and Potential experiment during the dark portion of an orbit. When the images were later developed on the ground a glow was found emanating from a region 5 to 10 cm thick just above the surface of the Orbital Maneuvering System pods. When *Columbia's* thrusters were fired the glow increased and whenever a surface was exposed to the direct flow of the thin atmosphere it appeared. It was particularly evident over the tail and OMS pods, and a fan-like glow was also seen reaching out a few metres from the tip of the tail.

The glow appears on the right hand sides of the tail and OMS pod during STS-3 in March 1982. *All illustrations NASA*



STS-8 and the cargo bay faces directly along the line of motion - the OMS pod's upper surfaces therefore glow the brightest.

The Cause

One of the methods used to determine the thickness of the glowing layer was to observe stars in the background while the Orbiter was in a slow roll. Knowing the roll rate and the time for a star to disappear behind the glow, the layer thickness can be calculated. This value depends partly on the atoms or molecules involved; atomic oxygen was found, not surprisingly since it is a major constituent of the atmosphere at these heights.

STS-4 mission commander Tom Mattingly used a diffraction grating attached to a camera to produce spectra of the glow (i.e. dividing the light into its individual colours) during some of the dark periods of orbits with no Moon. The relative amount of each colour identifies the material producing it. The effect was fainter than on STS-3 because the mission was flown at a higher altitude but the largest was shown to be mostly red and extending into the infrared.

Astronauts Joe Allen and Robert Overmyer photographed the glowing layer of the atmosphere (100 km high) with an improved camera to determine the absolute brightness of *Columbia's* glow. Material samples were also attached to the Remote Manipulator System arm and the glow was found to be different for each type. A similar experiment was conducted on STS-8 in September 1983.

On STS-9 (Spacelab 1) the crew used the same camera as on STS-5 and one of the pallet-mounted instruments (Imaging Spectrometric Observatory) also looked for the glow. The results are still being analysed.

It is difficult to distinguish one source of light from another because there are several in the cargo bay.

although quite slowly so that it was not readily apparent. By turning my head I recognised the spinning sensation; most of the passengers thought it was mysterious but fun.

Then the campers have a look at the Neutral Buoyancy tank where astronauts train in space suits underwater. Finally, they go to a swimming pool on the University of Alabama campus to practise retrieving objects from the bottom. This gives them an idea of how weightlessness feels.

Thursday is Tomorrow's Technology Day when they learn about careers in space. They also work with computers and launch the rockets made on Rocketry Day.

The highlight of the camp comes on Friday: Space Shuttle Mission Day. They simulate a mission as crew and ground controllers. Check-out, launch, emergency procedures, orbital operations and landing are all included. Finally, they attend an awards ceremony, then depart for home.

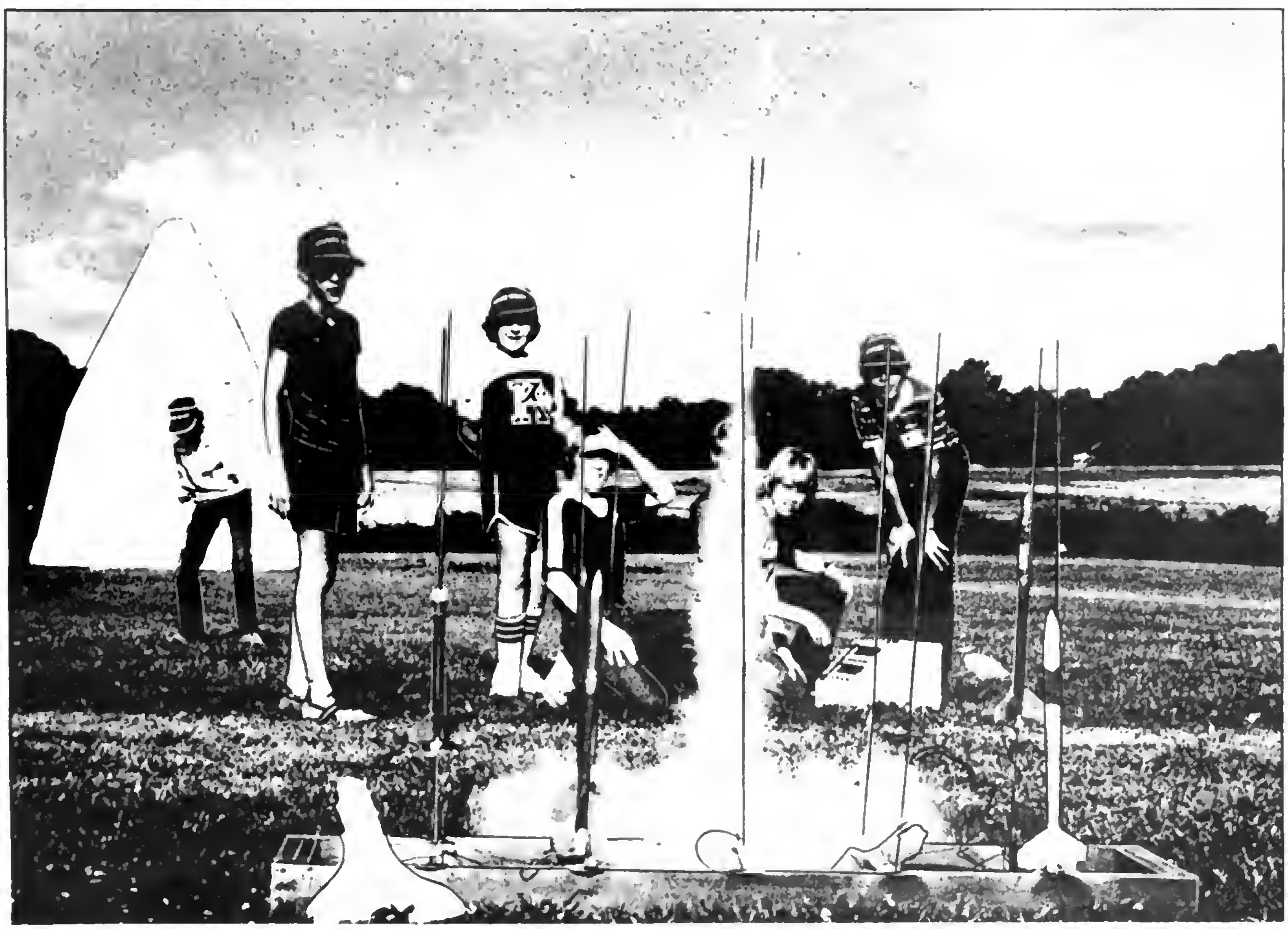
Another highlight is the Spacedome theatre, which uses the latest technology to create a thrilling experience. Slight curvature of the screen and its extra large size ensures that most of the viewer's peripheral vision is used by the image. The film is a larger format than the largest (70 mm) used in regular movies, thus retaining high resolution. Hence the film appears highly realistic and almost as if the viewer is watching an actual space mission in the feature *Hail Columbia*.

During their free time the campers explore the world's largest space museum. Since most of them were born after Neil Armstrong walked on the Moon, it is a good opportunity to learn space history. Real spacecraft and hardware are found throughout the museum. For example, the Apollo 16 Command Module is on display. Demonstrations include Shuttle tile heating, space suit pressurisation and a structural space beam.

Illustrating the heat protection of the Space Shuttle. *ASRC*

Space campers have come from all over the world: a quarter of them were from Alabama; most of the rest came from the southern US states. The object of the Space Camp is to stimulate interest in science among children with a unique educational experience. So far, it has been mission successful.

Campers launch rockets built by their own efforts.



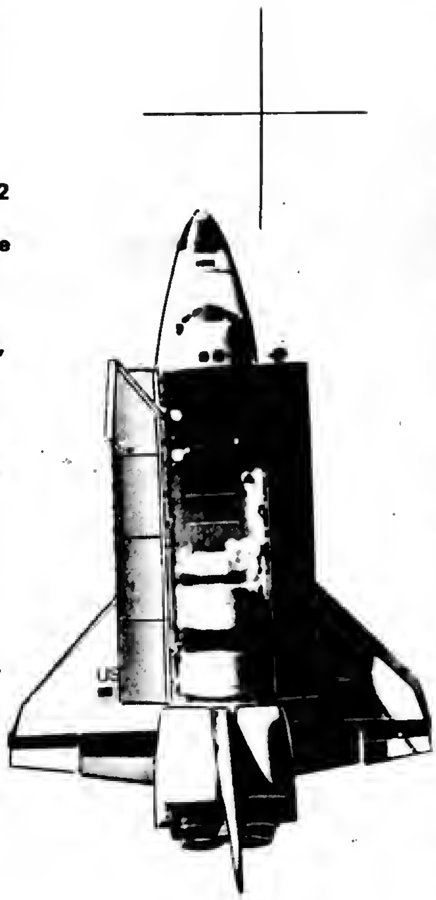
SOCIETY BOOKS

PROJECT DAEDALUS

The publication of the Project Daedalus Final Report marked the end of years of painstaking work by a group of BIS pioneers. The BIS received congratulations from around the world for its far-sighted project: designing a probe for man's first crossing of interstellar space.

The Final Report Report contains 24 papers spread over 192 large-format (A4) pages, summarising the four year study. The papers cover the overall spacecraft design, mission profile, computer systems, navigation, experiments and our knowledge of nearby stellar systems, some of them possibly with planets.

"Daedalus" is acknowledged as a milestone in the the development of advanced astronautics. Copies of the Report cost just £7.00 ($11.00) post free.



THE EAGLE HAS WINGS

An exciting progression of space achievements in the years following the Second World War led to Man's first landing on the Moon in 1969. Rockets for probing the upper atmosphere evolved into the space launchers we know today. Vanguard, Explorer, Atlas, Titan, Mercury, Gemini, Apollo – a succession of names to conjure up memories of the 50's and 60's when man was taking his first tentative steps into outer space.

The Eagle Has Wings tells the story of the major US Space projects from 1945 to the watershed year of 1975, when the Apollo missions came to an end and the first wave of interplanetary exploration gave way to the more sophisticated probes of today. Written by *Spaceflight* managing editor Andrew Wilson, it is packed with information and photographs. It runs to no less than 144 large-format pages and can be obtained for the low price of £7 ($11.00) post free.

HIGH ROAD TO THE MOON

Every member ought to own a copy of this unique 120 page publication which records many of the Society's early ideas and discussions on Lunar exploration in the visionary drawings and illustrations of the late R. A. Smith.

Pictures and drawings detail plans for orbital rockets, space probes and ships to take men to the Moon and Lunar exploration. Some are familiar illustrations used in books of the time: others have not been published before.

Bob Parkinson has brought these pictures together with a commentary which tells how the pioneers imagined things would be and how they actually were. It goes beyond the present, for man's involvement with the Moon is not yet finished. Using the Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.

Price: £6.00 ($9 .00) post free.

All of the books are available from: The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ, England

THE BRITISH INTERPLANETARY SOCIETY

ARMCHAIR ASTRONAUTS

By the Staff of NASA

A lone figure moves towards a failing satellite. The three hands begin their repair work. A third hand? Well, not a human one. All three, far beyond human capabilities, are attached to a highly complex robot controlled from Earth.

It is 1999 and robot satellite repairers have become commonplace in space, thanks to "telepresence."

Introduction

The Massachusetts Institute of Technology recently issued its final report on a year-long study of telepresence for NASA's Marshall Space Flight Center.

Telepresence uses a human being - with sensors attached to his body and by moving his head, arms and legs - to direct a robot to carry out human-like work. For example, a driver strapped into a remote control device in London could drive an empty car through the streets of Paris. By turning his head, the "driver" would cause a camera in the car to move, allowing him to see the camera's view - just as if he were actually there.

"It would be the same in space," said NASA'S Georg von Tiesenhausen, study manager of robotics in the Advanced Systems Office at the Marshall Center. "With telepresence, you could do things in space as if you were really there."

For the near future MIT looked at telepresence for an astronaut working outside a spacecraft. "We want to be able to match the human capabilities of EVA with the mechanical capabilities of telepresence using only current technology," said Von Tiesenhausen.

"We hope to have a flight test aboard the Space Shuttle and use a machine with robotic arms in the payload bay. The robotic machine might manipulate a test board and we could study some basic telepresence activities."

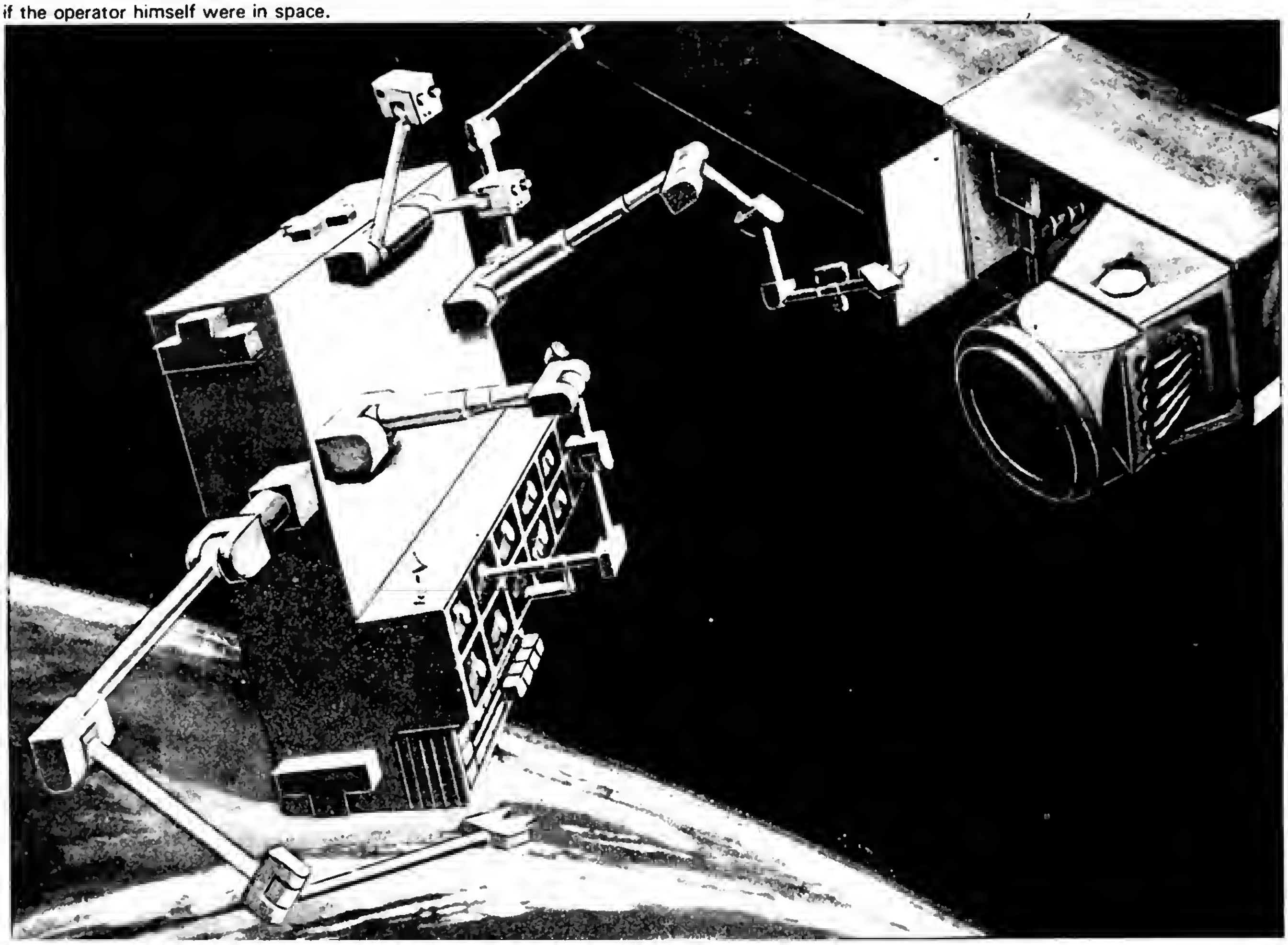
Replacing the Astronaut

Von Tiesenhausen explained why telepresence is superior to EVA: "If an astronaut wants to go outside the spacecraft, he has to suit up. That takes time. And then astronauts tire; a machine doesn't. Finally, telepresence is safer. We believe that telepresence capabilities will be at least equal to human EVA abilities by the 1990's.

"For the late 1980's for example, we're going to use black-and-white stereo TV cameras to enable the human operator to see well enough to have a sense of 'being there.' The images produced by those cameras, however, are inferior to images produced by human eyesight. Black-and-white cameras have a relatively narrow field of view. By the early 1990's we hope to match the capability of telepresence vision to that of human eyesight. But to see in colour and a wide field of view requires a far higher number of communication bands," said Von Tiesenhausen.

"The human eye can also concentrate on the centre of

A telepresence actuator reaches out to a large structure in space to repair an internal mechanism. Controlled from the ground, the multi-armed actuator would be equipped with lights, stereo TV cameras and tactile sensors to allow the Earth-bound operator to perform the work just as if the operator himself were in space.



the field of view. At present TV cameras can't do that".

For the end of the century, the study recommends vision to exceed that of human eyesight. "By the year 2000," said Von Tiesenhausen, "we want cameras which will give us holographic imaging, that is, a three-dimensional capability that exceeds even stereo cameras. Cameras and human eyesight now share a common drawback: as the distance between an object and the eye increases, depth perception fades. Everything at a great distance seems flat. With holograms, you can look around the sighted object, even if it's a good distance away.

"We also expect to have systems that will give us 'predictive' video displays. Those are images on a screen that tell us what the machine will be doing before it actually does it. Take, for example, a telepresence machine on the Moon while the operator is on Earth. There would be a 2.5 second delay from the time a command was sent by the operator until he received confirmation of execution. With predictive vision, the image would analyse a number of data, such as the speed and direction of the robot arm, and would project the movement - 2.5 second ahead - onto the operator's viewing screen."

MIT also pointed out the need for a sense of touch. In the near term, an operator will rely only upon his eyesight to grasp an object. By the early 1990's, the hand-like device may match human capabilities by using "proximity" and "force-feedback" sensors.

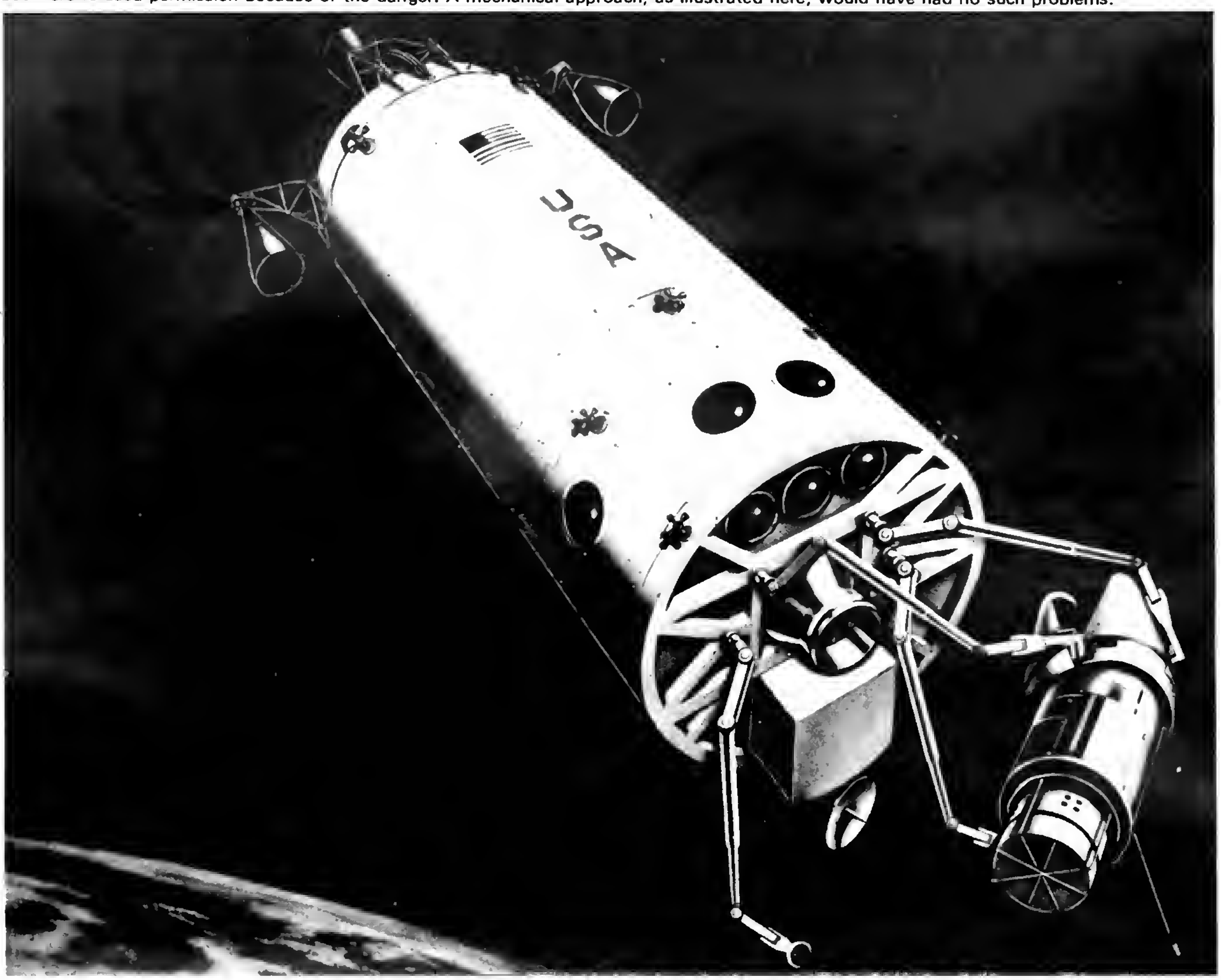
"A proximity sensor," explains Von Tiesenhausen, "could generate a tone as the robot hand approached an object. The closer it comes to its target, the tone would rise, to a high squeal."

After the tone stopped, the force-feedback sensor would take over. It would send a message to the operator - one he could actually feel in his own hand on the amount of force needed to grasp the object. The sensors should also be able to tell us whether the object is hot or cold, whether its texture is rough or smooth, or even if it's a certain shape, like round or square.

"We would also like to employ more than two robotic arms in a telepresence machine. That naturally presents a problem, since a human operator would move two robotic arms by telepresence with each of his own arms. How to control a third arm presents a real challenge. A third arm could grasp and hold the object while the other performed maintenance upon it."

Von Tiesenhausen forsees telepresence machines advancing not only in manipulative skills but in artificial intelligence as well. "As telepresence evolves," he said, "we will want the machines to perform tasks with only broad supervisory commands. In the near term, telepresence will require the human operator to command the robotic machine step by step. Beyond that, we expect the artificial intelligence level to have advanced to the point where the operator becomes less and less involved in the moment-to-moment actions of the machine."

An earlier concept of using manipulators to perform work in space. On a historical note, the captured satellite bears a remarkable resemblance to the Gemini 9 docking target of 1966. The launch shroud (seen here at the far end) failed to separate properly, prompting astronaut Tom Stafford to comment that it looked like an angry alligator. The crew suggested attempting to release the metal strap holding the shroud in place but were refused permission because of the danger. A mechanical approach, as illustrated here, would have had no such problems.



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SPACE AND ASTRONOMY

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Please contact the Executive Secretary if you think you can help.

GEMINI 4 : WHERE ARE THE EVA PICTURES?

By H.J.P.Arnold

When Ed White made the first US spacewalk on 3 June 1965 during the Gemini 4 mission he carried a camera on his manoeuvring 'gun.' Scant attention has been paid to the photographs from this camera. The subject was raised in *Spaceflight* in May 1983 pointing out that little has been seen of any of these images. The author's investigation into these pictures was published in the May issue of "Space Chronicle" JBIS. Here is a brief summary of the results.

Introduction

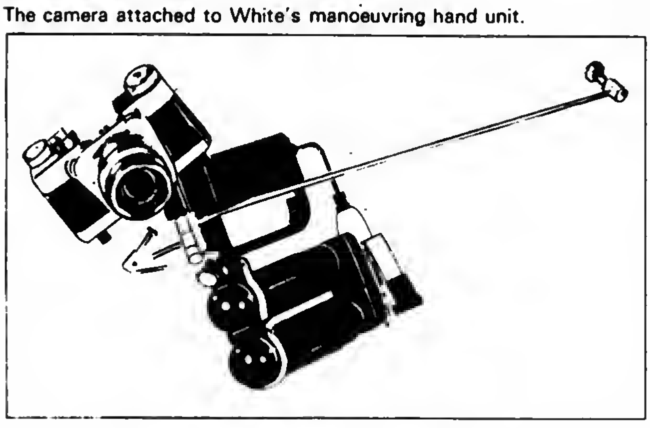
Although regarded officially as one of the secondary objectives of the mission, the spacewalk inevitably aroused great interest. An intrinsic part was the first test of an oxygen-powered hand-held manoeuvring unit (HHMU) or "gas gun." The idea of mounting a camera on the gun is attributed to the then director of the Manned Spacecraft Center in Houston, Dr. Robert Gilruth. The purpose was twofold: to secure a visual engineering record of the vehicle's condition following launch and also to obtain, for the first time, newsworthy photographs of a vehicle in space. The camera had to be mounted on the HHMU since White could not carry both separately.

The Camera

Fortunately, a camera was available that not only had the advantage of being ruggedly built but was one of the most technically advanced of that time. For some months, the US Air Force had been planning a series of photographic experiments for early Gemini missions. It is not clear now which USAF photographic experiments were scheduled originally for Gemini 4 and which for Gemini 5. It seems probable that the decision to perform an EVA on Gemini 4 shifted the emphasis of whatever USAF photography may have been planned originally from that mission to the next — and thus three experiments designated D1 (basic object photography), D2 (nearby object photography) and D6 (surface photography) were flown on Gemini 5 in the following August.

For these experiments the USAF had purchased a Zeiss Ikon Contarex Special 35 mm single lens reflex camera.

The camera attached to White's manoeuvring hand unit.



Some additional modifications were required to allow the camera to be used by an astronaut wearing bulky gloves, such as a bigger film wind lever and shutter release button, and the viewfinder system was dispensed with because White could neither put the camera to his eyes nor use a waist-level viewfinder.

Ansco D-200 transparency colour film was used at a fixed "nominal" exposure of 1/500 s at f/11. It was obviously hoped that the use of a 200 ASA fast film — and thus a high shutter speed and an aperture with considerable depth of field — would reduce the difficulties which White would encounter in America's first spacewalk.

The Results

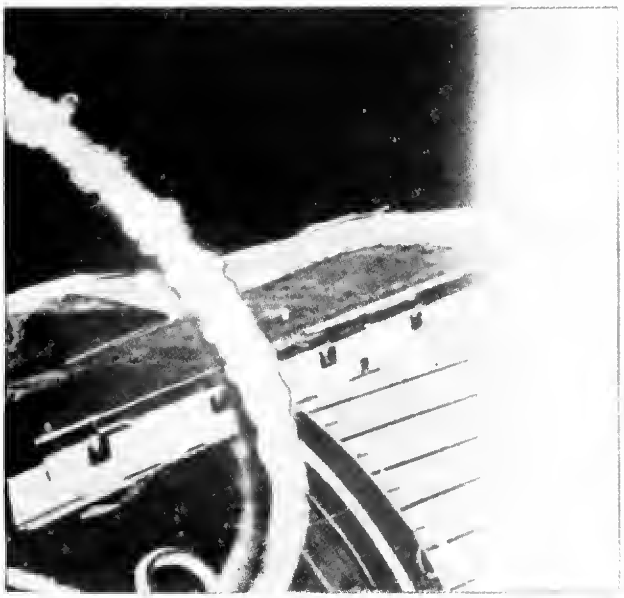
White exposed up to 40 frames and the film was analysed by Richard Underwood at MSC. The entire film has also been examined by the author. It is evident that White exposed at least 12 frames outside the spacecraft. It is not clear whether Frames 13 to 17 were shot outside but Frame 18 was certainly exposed after White's return. It seems that 13 in all were taken during the EVA with those inside beginning at Frame 16.

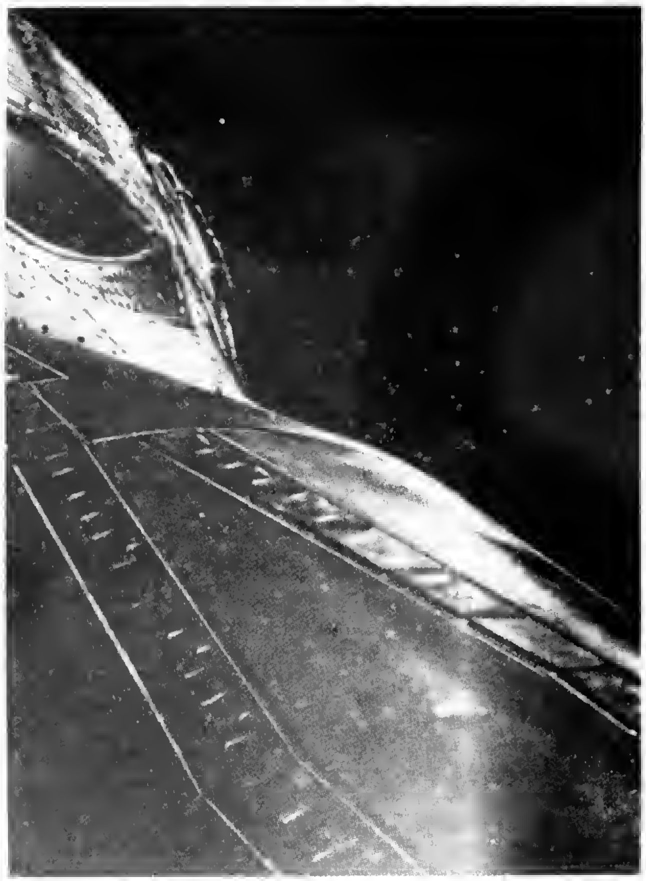
The quality of the whole film is very uneven, with a few excellent shots alternating with heavily underexposed subjects and complete blanks. This same uneveness is seen in the 12 frames certainly from the EVA. Two (Frames 2 and 3) show signs of light leak.

The overall level of underexposure in the EVA images could mean that the nominal exposure selected was incorrect for the lighting conditions which White encountered — or that possibly the camera controls were set incorrectly. (That this crew was capable of high quality photography can be seen in many other images obtained during the mission).

Frame 2 was released by NASA (reproduced in the correspondence columns of *Spaceflight* in the September/October 1983 issue) but, to the best of the author's knowledge, no others were generally released.

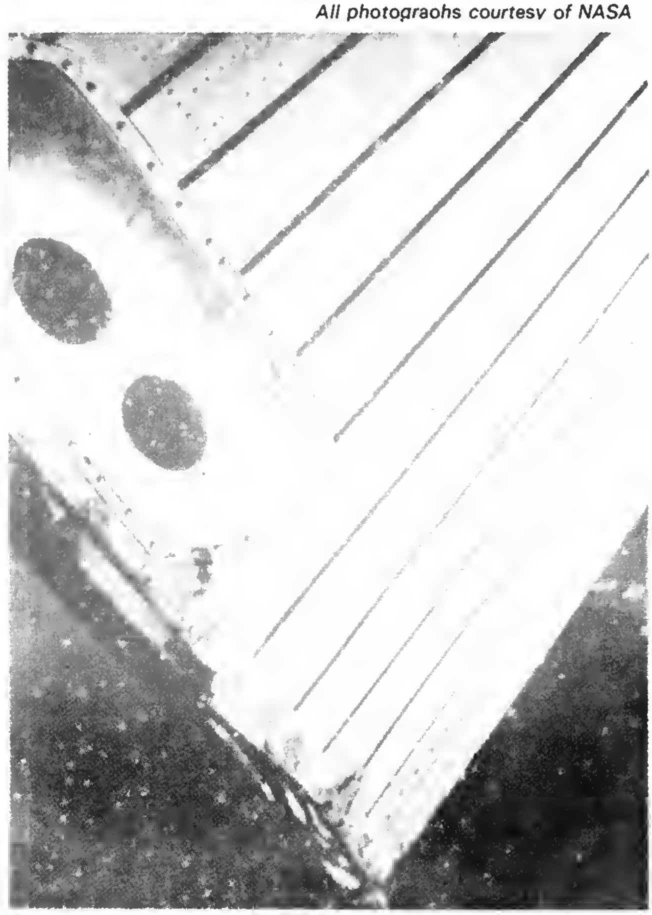
The question initially raised by a reader in *Spaceflight* about the photographs taken by White was well put. The author has found nothing untoward in the official attitude to the release of the material. One image (at least) was released at the time and another (Frame 12) was published later in a NASA technical paper. The rest were of indifferent quality and were swamped by the quality of other photography from Gemini 4 and later missions.





Top left: the basic EVA Contarex Special camera body. *Top right:* frame 2 of White's film shows Gemini's nose and McDivitt's window. *Left:* frame 1, White's umbilical snakes out of his open hatch; note the fogging at right next to the film leader. *Below left:* McDivitt appears to have caught White in the act of winding on his film. *Below right:* frame 12 shows two altitude control thrusters at the back of Gemini's adapter.

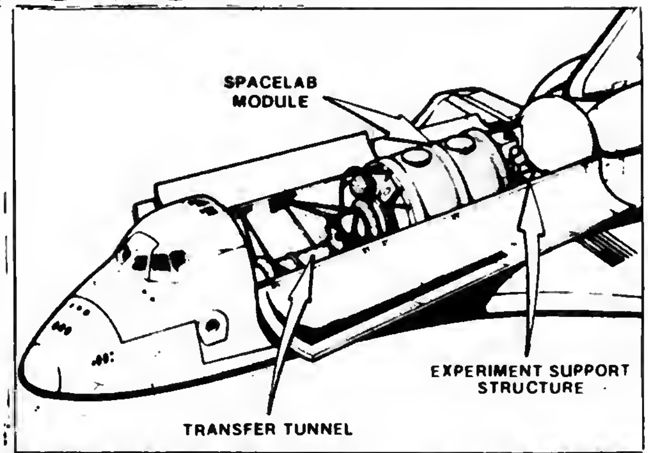
All photographs courtesy of NASA



THE FIRST OPERATIONAL SPACELAB

By John Bird

The Spacelab 3 mission next November will see the first operational flight of the laboratory system. While Spacelab 1 demonstrated the basic capabilities in a wide range of experiments last December, its successor will concentrate on materials science. (Spacelab 2, an astronomy flight, will be launched next March). Readers will be pleased to know that the Shuttle will again be passing over the more northerly latitudes and should be visible from the UK.



The basic Spacelab 3 layout. It looks almost identical to Spacelab 1, apart from the external experiments at the rear. *NASA*

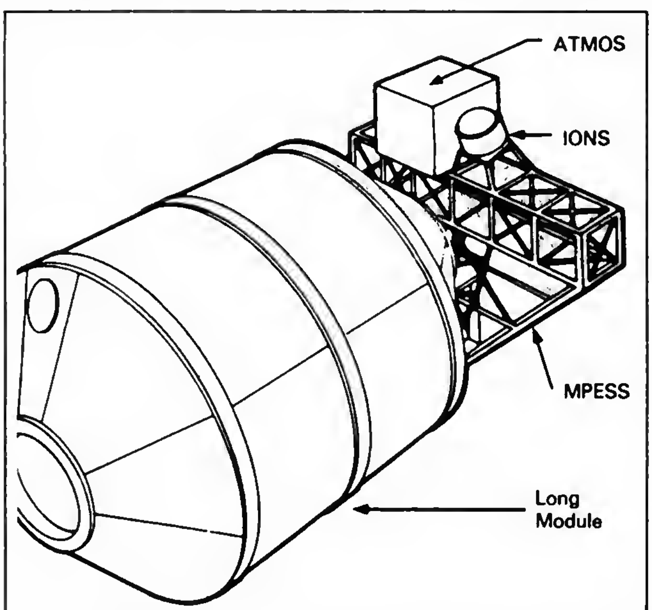
Introduction

Thirteen experiments from five disciplines are planned for the Spacelab 3 mission in November, the first operational flight of the laboratory, with the emphasis on materials science. The payload inside *Challenger's* cargo bay is a pressurised module (as carried by Spacelab 1) and an Experimental Support Structure instead of pallets, with 2,350 kg of experiments in total. Many of the experiments require few thruster firings so gravity gradient stabilisation will be used, with the Orbiter's tail pointing towards the Earth in its 370 km orbit inclined at 57° to the equator. The landing will be at Kennedy Space Center in Flordia after a seven day trip.

The Experiments

The payload includes monkeys and rats, with a high demand on the environmental control system. Dr. Randy Humphries, Chief of the Life Support and Environmental Branch at NASA/Marshall Space Flight Center, explained that the animals are equivalent to two humans as far as oxygen consumption and loading on the thermal control system is concerned. He noted that the Spacelab 1 system performed flawlessly, showing a consumption rate of nitrogen and oxygen less than expected.

The materials processing experiments will all be located in the habitable module. One series will grow crystals in the Fluid Experiment System to develop techniques for producing them in space, seeing how they grow and looking at their properties. The growth of the crystals from a solution will be monitored optically and compared with the same experiment on Earth, presumably showing that the space variety are better formed. Looking further into the future, such crystals could form the basis of infrared detectors.



Another crystal experiment involves mercuric iodide crystals which could be used as nuclear radiation detectors. By vaporisation and recondensation, they will undergo a diffusion-controlled growth in order to prevent dislocations that normally occur on Earth due to their own weight. Earlier experiments were done on Skylab (1973–4).

In fluid mechanics the 'Dynamics of Rotating and Oscillating Free Drops' experiment will observe the shape and motion of a rotating liquid droplet at various turning speeds. Cameras will monitor the 0.6 to 3 cm diameter water or silicon oil blobs as they turn at up to ten revolutions per second.

Another fluid mechanics experiment is the Geophysical Fluid Flow Cell Experiment, which uses a rotating spherical shell containing a fluid to simulate the dynamics of oceans and atmospheres on the Earth and other planets. It should provide us with some insight into the dynamics of cloud patterns on Jupiter and Saturn. The shell contains concentric spherical shell, with the fluid between. Dyes will be injected into the fluid to trace the flow and the resulting patterns will be photographed.

Life sciences experiments are also carried in the racks of the Spacelab module. One of these is the Research Animal Holding Facility-Verification Test in which four monkeys and 24 rats will test the facility for future use, especially the lighting, environmental control, display and water delivery. The Dynamic Environmental Measurement System will record the noise, vibration and acceleration in the rack beside the monkey cage. The Biotelemetry System will monitor transmitters in the animals themselves to record heart rates and temperatures.

Another life sciences experiment is the Urine Monitoring Investigation in which the crew's water intake is measured and their urine sampled for later analysis.

Two experiments will be outside on an Equipment Support Structure behind the pressurised module at the back of the cargo bay. The Atmospheric Trace Molecule Spectroscopy experiment will observe the Earth's upper atmosphere to determine its composition and obtain solar absorption spectra at various altitudes. An interferometer will track the Sun during sunset as its light passes through successively lower layers of the atmosphere.

The other experiment will study solar and galactic cosmic ray heavy nuclei such as carbon, nitrogen and

THE EXPERIMENTS

The 13 investigations cover five disciplines: materials processing, environmental observations, life sciences, technology and astrophysics. Two materials processing investigations will use the NASA developed Fluid Experiment System/Vapor Crystal Growth (FES/VCG) facility. A third, from France, is a reimbursible reflight of a Spacelab 1 experiment. The three materials processing investigations and a related technology experiment are:

Solution Growth of Crystals in Zero Gravity. Triglycine sulphate (TGS) crystals will be grown by a low-temperature solution technique in the FES. As heat is slowly removed from it, a seed crystal suspended in a saturated solution of TGS will grow. Growth in zero gravity and Earth gravity will be compared, using optical techniques (e.g. schlieren, shadowgraph and interferometry) to determine liquid density, solution concentration and temperature around the growing crystal. (R.B. Lal, Alabama A&M University).

Mercuric Iodide Growth for Nuclear Detectors. A specially designed furnace located in the VCG system will be used to grow HgI_2 crystals by the vaporisation and recondensation technique. Nearly perfect crystals are expected because the zero-gravity environment should eliminate gravity-driven fluctuations in growth conditions and strain dislocations produced by a crystal's weight. The growth of the seed crystal will be monitored by means of a microscope and can be reversed if polycrystalline growth begins. (W.F. Schnepple. EG&G, Inc.)

Mercuric Iodide Crystal Growth. A small, automated, two-zone furnace will be used to grow HgI_2 crystals by the evaporation and recondensation process. (R. Cadoret, Laboratoire d'Crystallographie Het et de Physique, France).

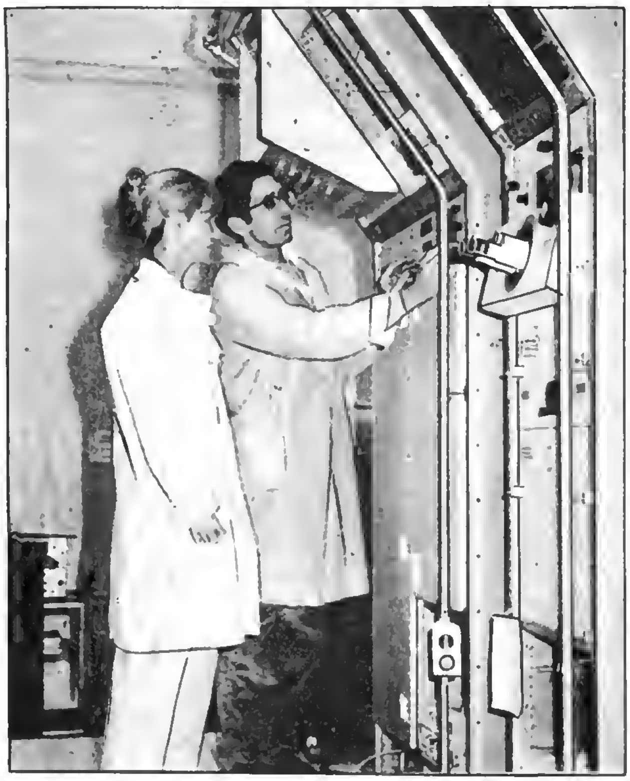
Dynamics of Rotating and Oscillating Free Drops. This investigation will study the equilibrium figure of a rotating drop and large-amplitude nonlinear oscillations of a liquid drop. Experiments will use the Drop Dynamics Module (DDM), in which three orthogonal acoustic fields can be used to position and excite drops of water and/or silicone oil. Three orthogonal views of the drops are recorded on 16 mm film. (T.G. Wang, Jet Propulsion Laboratory).

The six life sciences investigations, including four for verifying facilities to be used on Spacelab 4, are:

Ames Research Center Life Sciences Payload. Verification tests will be performed with two Research Animal Holding Facilities, the Biotelemetry System and the Dynamic Environment Measurement System. One RAHF will contain 24 rats; the other will have 4 monkeys. Similar animals will be an essential part of subsequent life science missions; therefore, this effort is directed toward demonstrating that the RAHF is a proper facility for these animals. The RAHF environment and animal activity will be monitored during flight. The BTS will measure basic physiological functions (e.g. deep body temperature and heart rate) of the test animals. The DEMS will monitor acceleration, vibration and noise during launch, re-entry and landing. (J.W. Tremor, Facility Science Manager, Ames Research Center).

Johnson Space Center Life Sciences Payload. The hardware associated with this investigation, the Urine Monitoring System postflight analysis, is located in the Orbiter mid-deck. Urine volume and content data obtained by means of the UMS and food and water intake data recorded by the crew will support a number of future experiments studying body fluid disturbances associated with adaptation to weightlessness. (H. Schneider, Facility Science Manager, Johnson Space Center).

A Preventive Method for the Zero Gravity Sickness Syndrome: Autogenic Feedback Training for Vestibular Symptomatology. Preflight training using two self-regulating methods, autogenic therapy and operant conditioning (biofeedback), will be administered in an attempt to limit the effects of the space sickness syndrome. (P.S. Cowings, Ames Research Center).



Drs. Johnson (left) and van den Berg train on the Fluid Experiment System and the Vapor Crystal Growth System. *NASA*

The two environmental observation investigations, which concern processes in planetary atmosphere, are:

Geophysical Fluid Flow Cell (GFFC) Experiment. Large-scale baroclinic (density-stratified) flows that occur in the atmosphere of planets and stars will be simulated through the use of a dielectric fluid confined between concentric, rotating, electrically conducting spherical shells. Each experimental run is made at a fixed rotation rate with an electric potential applied between the shells to simulate gravity while the temperature difference between the shells is raised slowly. A film camera documents the resulting flow patterns. (J.E. Hart, University of Colorado).

Atmospheric Trace Molecule Spectroscopy (ATMOS). ATMOS is a Fourier transform infrared spectrometer that views the Earth's limb and records solar spectra with absorption features caused by atmospheric constituents. From the spectra, the compositional structure of the upper atmosphere and the related physics and chemistry can be determined over a range of latitudes, longitudes and altitudes. (C.B. Farmer, Jet Propulsion Laboratory).

A single astrophysics experiment involves studies of highly ionizing cosmic ray particles; it is:

Studies of the Ionization States of Solar and Galactic Cosmic Ray Heavy Nuclei (IONS, also ANURADHA). Studies of the chemical composition, energy spectra, and charge states of cosmic rays yield information about sources and acceleration processes. The chemically-etched trails of particles in special plastic sheets provide the charge and energy data. (S. Biswas, Tata Institute of Fundamental Research, India).

oxygen. A 44 cm diameter plastic plate in a spherical aluminium housing will be inspected after the mission to record the tracks left by the 'heavy' particles as they passed through.

The Astronauts

There will be seven crew members: two pilots, three Mission Specialists and two Payload Specialists. Four Payload Specialists are in training: Dr. Mary Helen Johnston, of NASA's Marshall Space Flight Center; Dr. Lodewijk van den Berg of EG&G Corp. in California; and Drs. Eugene Trinh and Taylor Wang of JPL. The two who are not chosen to make the trip will serve as backups and will assist on the ground during the mission at the Payload Operations Control Center.

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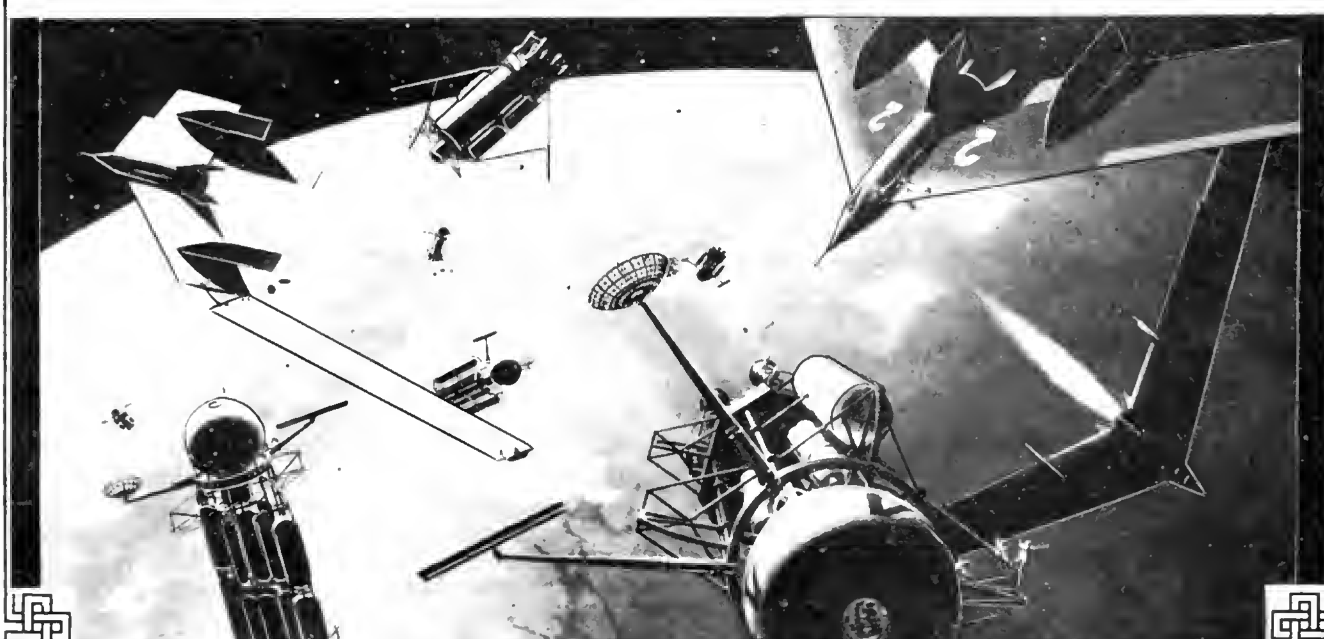


PERSONAL PROFILE

GORDON L. HARRIS

Readers of our "News from the Cape" Section will be familiar with the name of Gordon Harris, its author. His unique career has brought him into close contact with the people and events surrounding the major US space stories; Explorer and Apollo are especially prominent. Many a Society member will envy him his memories!

In at the Deep End

In 1955 the Army Ballistic Missile Agency was hurriedly authorised to begin development of missiles to counter those of the Soviets. The Army wanted an intermediate range missile, Jupiter, produced, in the shortest time possible, together with Redstone, a 320 km range missile.

Vested with extraordinary authority, Major General J.B. Medaris took over the Army's prime rocket team, headed by Wernher von Braun, at Redstone Arsenal in northern Alabama. Next door was the town of Huntsville, first capital of the Confederacy and for years centre of a cotton-growing region.

By early autumn 1956 the key ABMA staff members were at hand, with one exception. Medaris wanted an information officer to deal with the press and public, capable of walking a narrow line between security and disclosure. His deputy, Brigadier General J.A. Barclay, nominated me, then a management assistant at Picatinny Arsenal in New Jersey, a principal Ordnance research centre.

I became acquainted with Barclay while he was commanding Picatinny. I was a graduate of Columbia College in New York City (King's College before the Revolution) and the Pulitzer School of Journalism. I was also a member of the town's school board and had directed its recreation commission and parking authority. Barclay reasoned that this background ought to equip me to work with Huntsville officials during a time of rapid growth.

And Barclay reminded Medaris that I had a military background, including counter intelligence experience in Manila during World War II. I was recalled to active duty (as Major) during the Korean conflict, serving as chief of administrative services at Picatinny and later as assistant inspector general, Eighth US Army, in Seoul.

Barclay got in touch in September, 1956 and I visited General Medaris and agreed to report for duty 10 days later, with civilian status.

Working in Huntsville

I soon discovered that a tight security blanket shrouded ABMA's activities and its people. While there was press curiosity about von Braun, his Peenemuende work and the oddity of his employment by the US Army, very little could be said about Jupiter. Even its configuration was secret. General Medaris was a newcomer so far as media knowledge was concerned although he had a distinguished career dating to service in France as a young Marine in World War I.

We were both in demand for speeches to professional audiences – organisations related to ordnance, astronautics and rocketry. These were hardly public appearances but in some cities press conferences for the visiting speakers brought in radio and television as well as press. Among my jobs was the preparation of speeches, requiring

Miles Ross, acting KSC director after the retirement of Kurt Debus, presents me with a retirement certificate.

tents to suit the occasion and introducing wherever possible a restrained mention of space. It was always with a wary eye to the Pentagon reviewers who screened every statement. No hint of dissatisfaction with funding or any rivalry with the Air Force, then engaged in developing Thor, a counterpart to Jupiter, was tolerated.

I travelled extensively with Medaris and von Braun to smooth their relations with the media and to gauge the reactions of their audiences to my scripts.

Meanwhile, I discovered that other former Germans (there were about 100 of the Peenemuende team in ABMA, some in top positions) had little interest in press or public contacts. These were dedicated professionals, immersed in the challenges of their pioneering work and, in most cases, too self-conscious of their accents. At the time, such an accent was the hallmark of authenticity – these were true rocketeers – but they refused to believe it.

Men like Eberhard Rees, von Braun's tireless deputy, Geissler, Hoelker, Heimburg, Maus, Rudolph and others, each responsible for a key phase of Jupiter development, could not be induced to meet newsmen. "Go see Braun," was the inevitable response.

There was a lone and welcome exception. Dr. Ernst Stuhlinger, chief of research projects, talked with reporters when – as often happened – von Braun was not available. Early on, I escorted Jim Lucas, correspondent for the Scripps Howard newspaper chain, to interview Stuhlinger. Any discussion of Jupiter was barred, so Lucas asked how man could reach the Moon, an idea which in late 1956 was still in the realms of science fiction. For an hour Stuhlinger talked, using a blackboard to sketch trajectories or jot down salient points while Lucas listened in silence. He did not take a single note.

When Stuhlinger put down his chalk, Lucas commented: "I've listened and watched as you told me how man could fly to and from the Moon. You speak of these things so matter of factly that it is very hard for me to

Stuhlinger smiled and quietly said: "You see, Mr. Lucas, you are thinking of it for the first time. We've been thinking and planning for 25 years."

There was no complaint from the Pentagon when the sketchy account showed up in print. It all seemed so far-fetched that the censors ignored the story!

Community relations were of little concern. Huntsville's leadership was so enamoured of the Army activity and its huge budget that growth was accepted as a natural result. And what the Army wanted, the community would provide. Even to defying Alabama law by adopting daylight saving time so that Medaris would be in a better position for communications with Pentagon and contractors in the Northeast.

The Impact of Sputnik

I was at home on the night of 4 October 1957 when an Army operator, following instructions, referred a press to me. The London *Times* was calling and wanted some comments from von Braun.

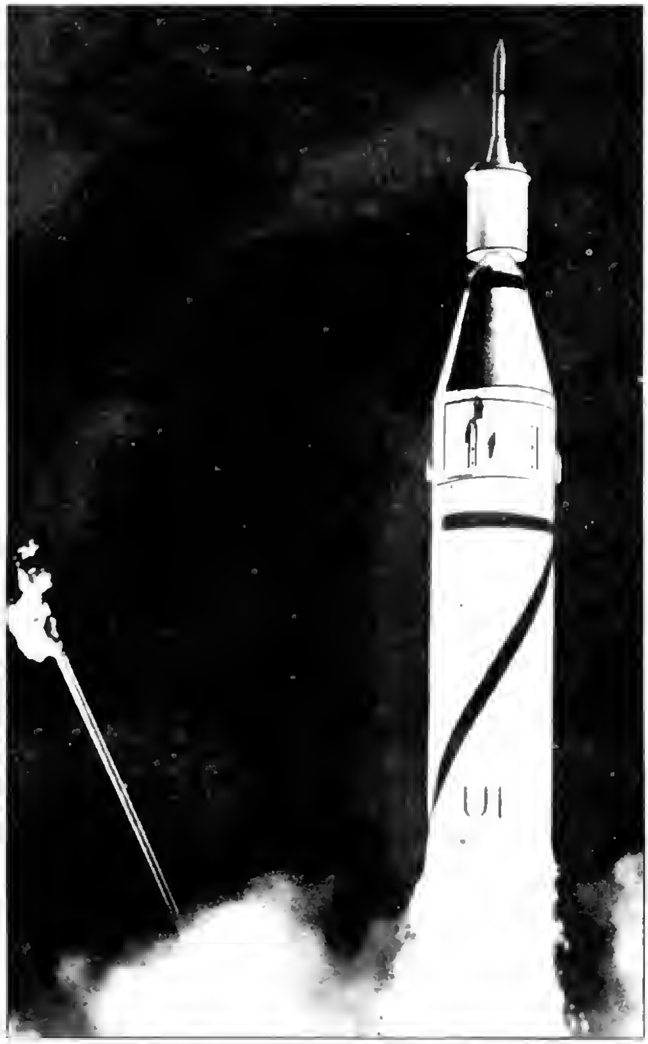
The Jodrell Bank Observatory had reported the Soviets had launched Sputnik, they also supplied early estimates of the orbit and Sputnik's mass. "What does von Braun have to say about this?" asked the reporter. I replied that he could not be reached and immediately notified General Medaris at dinner in the Arsenal officer club with von Braun, the incoming Defense Secretary Neil McElroy, and others. Hardly surprised, von Braun passionately renewed his plea for a satellite mission. The Eisenhower Administration and Pentagon had earlier turned him down and had given the project to the Navy. Medaris interrupted to say "We can do it in 90 days." McElroy made no promise and left next day. The *Times* got no comment, neither did the press and TV crews who converged on Arsenal gates. The Pentagon forbade any statement.

The story of America's first satellite, Explorer, has been reported many times. To the ABMA team, finally given the go-ahead after Sputnik 2 in November 1957, it meant round-the-clock activity. We had secretly launched a Jupiter C rocket in September 1956 that had soared 1000 km into space and travelled 5,000 km down the Atlantic Missile Range. Medaris chafed under orders that directed him not to hurl the payload into orbit.

A scanty account of that flight appeared in a magazine of limited circulation and triggered investigations to uncover the miscreant who "leaked" the story. The source was never found but Harris and assistants were not above suspicion. On two occasions over several years the Army placed undercover agents in my office to hunt unsuccessfully for "leakers."

Meanwhile, conscious of distrust and dislike of von Braun in influential circles, particularly in the New York area, Harris sought to convince sceptics that this blond, articulate manager was sincere in adopting American citizenship. An Atlanta (Georgia) baseball team provided opportunity. Would von Braun throw out the first ball of a game? – an honour usually reserved for politicians. I got Medaris' approval and then persuaded von Braun. For several days, after hurriedly eating grapes for lunch, Wernher practised throwing a baseball to an amateur player in the parking space outside his office. He went to Atlanta and played out his assigned role. Atlanta newspapers spread the story on sports pages, wrote of his "curve ball" and said he'd make a good pitcher if he gave up rockets. The Army would have been hard put to find a more traditional American debut.

The White House came under a blistering attack by Congress and the press for allowing the Soviets to seize a leading role in space. Medaris received secret orders to



This modified Jupiter C (based on the Redstone, confusingly, and not the Jupiter) took America into the Space Age in 1958. The "tub" carried 14 small rockets to power the satellite towards orbit, the final push being given by the single motor on top of the spinning tub. This motor and the payload became the 14 kg satellite (Sputnik 1 weighed 83 kg).

quietly with Earl Newlin of the Jet Propulsion Laboratory, to which Medaris assigned the task of packaging a satellite, and Joe Jones of my office, a press kit of more than 100 pages was assembled and duplicated. All material intended for release had to be acceptable to Army and Defense reviewers in the Pentagon.

The Navy tried to launch the highly-publicised Vanguard in early December and the vehicle collapsed and burned on its pad. Pressure mounted steadily on ABMA and the launch group headed by Kurt H. Debus at Cape Canaveral. Jupiter C (also known as Juno I) was erected and shrouded in canvas. When the launch neared, Medaris dispatched von Braun and Dr. William Pickering of JPL to Washington where the National Academy of Sciences coordinated US participation in the International Geophysical Year. The General flew to the Cape and assigned me to a three-legged stool in the Army's blockhouse, using a telephone to relay information to the site where 200 newsmen had gathered, and to the Pentagon.

Twice delayed by unfavourable winds, Jupiter C was launched on the night of 31 January 1958 (in less than 90 days) and Medaris remarked: "We kept the faith."

Perhaps because so little information had appeared about the attempt, as Medaris wanted, the nation reacted with surprise, pride and obvious satisfaction. Medaris and von Braun were hailed as heroes. Congress, the press,

appearances. Medals and honorary degrees followed in profusion.

Suddenly, I was faced by an entirely different situation. No longer had I to knock upon editors' doors – they clamoured for access. It was physically impossible to meet all of the demands for information, photographs and speeches. The Army hit upon a device to relieve von Braun of some pressure. He was allowed to contract with a lecture agency which would book him at fees ranging from $1,500 to $2,500 for 10 appearances per year. Medaris felt that was enough. I helped by screening the requests and writing the speeches to make sure that von Braun stayed within policy bounds – and mentioned the Army favourably!

It was not all triumph. Competition between the Air Force, developing Thor, and the Army over control of the IRBMs became so intense that the Dept. of Defense limited the Army to missiles of 320 km range (Redstone) but allowed ABMA to continue the development and production for Jupiter's deployment in Italy and Turkey.

The Army recognised Medaris in a more tangible way. He formed an Army Ordnance Missile Command with responsibility for all types of rocket powered weapons. His former trust, Army Ballistic Missile Agency, became part of AOMC. So did a new Army Rocket and Guided Missile Agency for air defence and tactical weapons systems. White Sands Proving Ground, New Mexico, where von Braun and his Peenemuende veterans launched V-2s from 1946 until their move to Huntsville in 1950, and the Jet Propulsion Laboratory rounded out his command. I supervised the press and public relations for these divisions.

Redstone and Jupiter were deployed in NATO while Medaris focused attention on space, beginning the development of Saturn to provide a clustered million-pound thrust booster. More Explorers were launched, as well as Pioneer in solar orbit. The AOMC information shop turned out press packets, films and photographs for these events.

Goodbye to Huntsville

After Congress adopted a National Space Act in 1958, President Eisenhower decided to transfer von Braun, his organisation and facilities to the new National Aeronautics and Space Administration. General Medaris fought the move and succeeded in delaying it while beginning development of Pershing, a solid propellant vehicle that would succeed Redstone in Europe and effectively eliminate that 320 km limitation.

But Medaris knew the Army's bid for a national space programme was dead. Project Horizon, a lunar base proposal, was pigeon-holed by the Dept. of Defense. NASA later received the Apollo assignment, which cost twice as much and took twice as long. Late in 1959 Medaris announced he would leave the Army in January 1960. I transferred to the Pentagon on 1 July 1960 as information chief for the Ordnance Department. Soon afterwards, I became Assistant Chief of Information for the Army.

A year later I joined Lt. Gen. Andrew McNamara, director of a new Defense Supply Agency, in charge of common supplies for the military. I set up an information programme for this national enterprise, buying and distributing billions of dollars worth of food, clothing, hardware and general supplies worldwide.

In time, the work paled by comparison with the excitement and challenge of space. I flew to Cape Canaveral in November 1963 on the invitation of Kurt Debus to discuss his need for a public affairs chief. Debus directed NASA's Launch Operations Center and supervised construction of the massive Apollo facilities. We soon agreed that I would join him the next month as the first chief of public affairs at the launch base. President Lyndon Johnson subsequently named the installation in honour of the martyred sponsor for Apollo, John F. Kennedy. It would become the most demanding and most frustrating position in my government career. For one thing, the Center was never officially dedicated. KSC proposed such a ceremony and the Johnson White House knocked it down.

There was, to the public affairs chief, a marked difference in the personalities of Debus and von Braun. The latter was outgoing, genial, ready always to promote space and its technology. He became its foremost advocate in the US. By contrast, Debus was modest, unassuming and, at least to the media, almost aloof. He would soon become an unofficial ambassador by greeting and briefing heads of foreign states, members of Congress, Governors, scientists, educators and industrialists. Walter Cronkite, the legendary newsman of the Columbia Broadcasting System, regarded Debus as one of the lesser known geniuses of American space progress.

During the Johnson presidency his Center became a showplace for the leaders of European, Middle East, African and Asian countries.

Debus gave me ample support. I managed a diversified organisation, including a protocol office which dealt with the State Department to arrange itineraries and receptions for kings, queens, consorts, premiers, prime ministers, ambassadors and consuls. James Loy, a former Army officer, headed the branch. Another, of which Jack King, one-time Associated Press correspondent was chief, dealt with press, radio, TV, magazines and motion pictures. A third, retired Colonel Paul Siebeniechen, chief, represented the base to community officials and organisations. William Nixon managed the fourth branch which, as part of a national project by NASA, supplied material and lecturers to schools and colleges in the Southeast. Some numbers suggest the scope: as many as 12,000 invited guests attended a single Apollo launch, requiring a fleet of 300 buses, covered by 3,500 media representatives from many foreign countries and the US.

Debus considered that active public support was essential to future programmes. Accordingly, he wanted to open his Center whenever possible. Working with deputy director Albert Sieptert, I helped to set up daily bus tours originating at a visitors' information building. A decade later tours attracted 1,500,000 people annually. Anybody could drive into a parking area, buy a ticket and see at first hand major launch installations on Cape Canaveral (managed by the Air Force) or NASA's Kennedy Center.

When Apollo peaked in July 1969, when the first astronauts walked the Moon, KSC employed 25,000. Of these, 3,000 were government personnel, while the rest worked for major contractors, those who built Saturn 5 stages, Apollo and lunar module spacecraft, or maintained the base. Public affairs employed 35 civil service personnel and up to 150 contractors who prepared fact sheets, answered voluminous public mail, furnished photography, or printing and reproduction. Indicating the importance he attached to public affairs, Debus placed me in an office suite 10 m from his. He made me a member of a key staff of 12 who met with him every Monday morning to discuss problems and review schedules.

Throughout the period, KSC maintained a busy schedule of unmanned launches using Delta and Atlas vehicles. Planetary probes, communications and meteorological satellites were all launched under Debus' supervision, including those designed for polar orbits launched from California. For all of these, press kits were distributed, media briefings were conducted before and after liftoff, and results were announced as soon as available.

There were unexpected setbacks. The most critical was

About 3,500 newsmen visited KSC for the launch of Apollo 11 on 16 July 1969 – and they all had to be catered for! *NASA*

a fire in Apollo which killed three astronauts in 1967. Overnight the friendly media attitude changed to bitter criticism. There were guesses that Congress might stop manned space flights. I came under press attack because I refused to name the victims or confirm the deaths until other astronauts had informed widows and parents. Reporters knew a test was in progress and the identity of the crew. Until official confirmation, however, they could only guess the worst had happened. During the investigations that followed, NASA kept the press fully informed. The twin successes of Apollos 7 and 8 in October and December 1968 overcame any lingering doubts of the agency's management.

Not until a mishap in flight threatened the Apollo 13 astronauts was NASA again under press suspicion. Again, I opened a KSC news centre, summoned help and dealt with newsmen's queries until the emergency was over. The follow-on triumphs of Apollos 14 to 17 restored confidence and support. For these missions KSC leased buildings in Cape Canaveral and Cocoa Beach to serve the press, and churned out thousands of news releases, entire transcripts of air-ground conversations, arranged interviews with key officials, and toured hundreds of still photographers and TV personnel. On days leading up to a launch, a fleet of buses transported newsmen from the two towns to an elevated mound constructed for the purpose at Launch Complex 39. There NASA installed a grandstand seating 350, by no means adequate for Apollo throngs.

The Skylab programme brought fewer press and distinguished guests – interest dropped noticeably because missions were flown in Earth orbit over greatly extended periods, and they lacked the mystique of those carrying men far from their planet. Planning for a reusable Shuttle led to a commitment by President Richard Nixon in 1972 and Congress provided funds to begin the design work. Two years later, Debus "turned the first soil" to begin construction of the Shuttle runway and hinted broadly that he was thinking of retirement.

Pressures generated by Mercury, Gemini, Apollo and Skylab had taken their toll. The man who built KSC informed his key associates that his health was adversely affected and he left soon afterward. I thereupon retired because of disability.

I had written a book, *Kennedy Space Center Story*, and brought out annual revisions which served as gifts for distinguished visitors. In retirement, I published *Selling Uncle Sam*, reciting my experiences in government public relations. Next, I brought out a biography of General Medaris, an Anglican priest now because of a seemingly miraculous recovery from osteosarcoma. A short novel, *Apostle from Space* is my latest effort; an unpublished biography of von Braun rests in my files at home in Cocoa Beach.

TETHERED SATELLITES

By the Staff of NASA

The Tethered Satellite System, the "satellite on a string" expected to be in orbit by late 1987, took a step closer to reality earlier this year when the NASA's Marshall Center directed the Martin Marietta company to go ahead with full-scale development.

Introduction

TSS will be carried by the Shuttle. In orbit, it will be suspended either down or up from the cargo bay on a tether - a super-strong synthetic cord 1.5 mm thick and up to 100 km long. When sent upwards, as it will be for its maiden mission in 1987, it will study electrodynamic and other scientific phenomena. Sent downwards, as it will be for later missions, it will 'troll' the Earth's upper atmosphere for magnetospheric, atmospheric and gravitational data.

Martin Marietta has completed engineering analyses and advanced development testing of some key components. Both Martin Marietta and Ball Aerospace had previously completed parallel studies. Martin was then selected to begin advanced development and, finally, the design and development phase in January.

NASA is sharing development with Italy. NASA will build the deployment system (the tether, reel, control system and the Shuttle's cargo bay), and Italy will build the satellite itself. NASA will also be responsible for systems integration and mission operations.

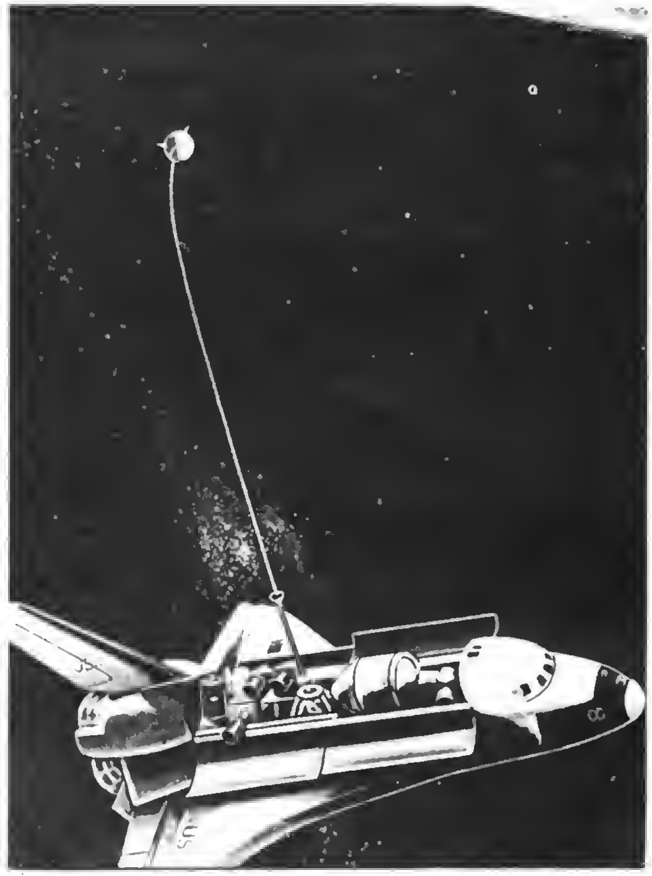
The Flight

The first flight in 1987 calls for upward deployment. It will be moved out 12 m by an extendible boom and checked out before release. As it moves 'up' from the Shuttle, the reel will unwind until the satellite is at its chosen distance for electrodynamic experiments. As the Shuttle passes through the space plasma - ionized gas particles surrounding the Earth - the satellite, with its conducting tether, can become a generator much as a copper coil moving within a magnet on Earth can produce the flow of electricity. By drawing off the energy from the tether and releasing it into space, scientists will be able to study the magnetic lines around the Earth.

"In fact, we'll even be able to simulate some electrodynamic conditions of the other planets in the Solar System," said Dr. Nobie Stone, project scientist. "For instance, one of the moons of Jupiter - Io - has volcanic activity that causes an ionosphere much like the Earth's to be formed. This makes Io a conducting body. As Io moves through Jupiter's magnetic field, a current is formed that flows from Io to Jupiter and back. From Earth, we have observed bursts of waves on Jupiter. These may come from this circular current flow between Io and Jupiter.

By deploying the satellite upwards, we hope to simulate the conditions between these two bodies. The satellite would act as the conducting moon Io. In just this one example, we can learn more about the nature of electrodynamics of our sister planets.

Sent downwards, the satellite fills a need that has long existed in the study of the upper atmosphere. "Currently there are only limited means by which the upper atmosphere, aound 100 to 150 km up, can be studied," said James Sisson, manager of the project. "The upper atmos-



Deploying a tethered satellite from the Shuttle down into the atmosphere.

balloons to reach, but it's low enough for the orbits of satellites to decay from the aerodynamic drag after only a few hours." A number of instrument-laden rockets have been used, with limited success, but they pass through the upper atmosphere for only a few minutes before falling back to Earth.

"Besides," said Sisson, "these rockets travel primarily up and down, so they provide only a vertical look at one point in the upper atmosphere. TSS however, could be pulled through its extremely low, circular orbit - perhaps only 130 km above the Earth - to study the upper atmosphere for days at a time. This would allow scientists to map the global currents known to exist."

The low orbit will allow the mapping of gravity and magnetic fields at higher resolutions. Or the low orbit could provide platform measurements in the atmosphere itself, rather than by remote instruments.

Other possible applications include radiation surveys, radio experiments, ocean topography mapping, and sound propagation studies.

This reusable satellite, with new instruments - or perhaps even a different satellite - can be reflown on the Shuttle. The formation of the US/Italian partnership began in 1980 when the Italian Government's PSN/CNR (National Space Plan/National Research Council) asked to collaborate with NASA on TSS which the agency had been studying since the mid-1970's. In 1981 a Letter of Agreement was signed to establish the tasks of each agency during the study phase. Another agreement has been negotiated for the actual joint development.

"We're looking forward to a challenging development effort in this cooperative endeavour with the Italian Government," said deputy project manager Jay Laue. "The system promises to further scientific knowledge of the near-Earth environment."

(An article on collecting cosmic dust with the tethered

SATELLITE DIGEST-175

Robert D. Christy

Continued from the June issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

SOYUZ T-10 1984-14A, 14701

Launched: 1207*, 8 Feb 1984 from Tyuratam by A-2.
Spacecraft data: Near-spherical orbital compartment, conical re-entry module and cylindrical instrument unit with solar panels. Length approx 7.5 m, diameter 2.2 m and mass around 7000 kg.
Mission: Carried long stay crew of Leonid Kizim, Vladimir Solovyov and Oleg Atkov to Salyut 7. Soyuz T-10 docked with the forward unit of Salyut 7 at 1443, 9 Feb 1984.
Orbit: Initially 198 x 219 km, 88.60 min, 51.58 deg, then manoeuvred to 227 x 270 km, 89.41 min for rendezvous, then was 289 x 297 km, 90.32 min, 51.63 deg after docking.

OHZORA (EXOS C) 1984-15A, 14722

Launched: 0800, 14 Feb 1984 from Tanegashima Space Centre by M-3S.
Spacecraft data: Cuboid with four solar panels, approx 1 m each side with mass 180 kg.
Mission: Aeronomy satellite participating in the Middle Atmosphere Programme (MAP), equipped with optical sensors to study the atmosphere at heights between 10 and 130 km. Ionospheric studies are also being undertaken, particularly in relation to the South Atlantic Magnetic Anomaly.
Orbit: 356 x 887 km, 97.18 min, 74.59 deg.

RADUGA 14 1984-16A, 14725

Launched: 0847, 15 Feb 1984 from Tyuratam by D-1-E + apogee motor.
Spacecraft data: Cylinder with a pair of solar panels and an aerial array at one end, length 5 m and diameter 2 m, and mass in geosynchronous orbit around 2000 kg.
Mission: To provide round-the-clock radio, telegraphic and TV within the Soviet Union and through the 'Orbita' system.
Orbit: Geosynchronous above 85 deg east longitude.

COSMOS 1537 1984-17A, 14737

Launched: 0815, 16 Feb 1984 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical, supplementary payload at the forward end. Length about 6 m, max diameter 2.4 m and mass around 6000 kg.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package. Recovered after 14 days.
Orbit: 259 x 273 km, 89.89 min, 82.35 deg.

PROGRESS 19 1984-18A, 14757 Tau-

ratam by A-2.
Spacecraft data: Similar in appearance to Soyuz T except that the re-entry module is replaced by a cone-shaped, non-recoverable module for stores. Length approx 7.5 m, diameter 2.2 m and mass around 7000 kg.
Mission: To carry consumables (including fuel) and cargo to Salyut 7 prior to the joint USSR/Indian mission. Progress 19 docked with Salyut's rear port at 0821, 23 Feb 1984. It undocked 0940, 31 March and the retro rocket was fired at 1818, 1 Apr to provide a destructive re-entry over the Pacific Ocean.
Orbit: Initially 185 x 245 km, 88.74 min, 51.62 deg then via a transfer orbit to 306 x 311 km, 90.62 min, 51.62 deg for docking with Salyut.

COSMOS 1538 1984-19A, 14759

Launched: 1539, 21 Feb 1984 from Plesetsk by C-1.
Spacecraft data: Possibly a cylindrical body with domed ends, housed in a drum-shaped solar array. Length and diameter both about 2 m and mass around 700 kg.
Mission: Military communications using a store/dump technique.
Orbit: 771 x 812 km, 100.73 min, 74.05 deg.

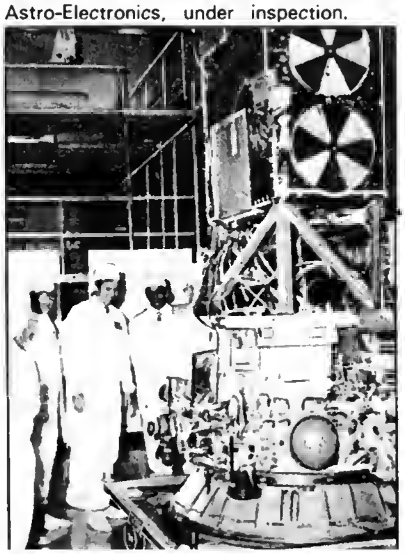
COSMOS 1539 1984-20A, 14763

Launched: 1400, 28 Feb 1984 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1537.
Mission: Military photo-reconnaissance, recovered or re-entered after 41 days.
Orbit: 169 x 241 km, 89.62 min, 67.17 deg, manoeuvrable.

LANDSAT 5 1984-21A, 14780

Launched: 1759, 1 Mar 1984 from Vandenberg AFB by Delta.

A NOAA weather satellite, built by RCA Astro-Electronics, under inspection.



Spacecraft data: Irregular cylinder with solar panel and dish aerial at one end. Length about 4 m, diameter about 2 m and mass around 2000 kg.
Mission: Remote sensing for Earth resources.
Orbit: 683 x 698 km, 98.64 min, 98.25 deg.

UOSAT 2 1984-21B, 14781

Launched: Pick-a-back with Landsat 5.
Spacecraft data: Cuboid, 0.8 x 0.3 x 0.3 m, mass approx 50 kg.
Mission: To develop further the programme started by Uosat 1 (1981-100B). There are three main areas of interest: space science, education and space engineering. To this end, Uosat carries an electron spectrometer for magnetospheric studies, a charge-coupled device for Earth imaging and a space dust detector. Additionally, a voice synthesiser transmit telemetry and news bulletins and a digital communications experiment is intended to allow amateur radio user to access a random memory for messages.
Orbit: 678 x 696 km, 98.56 min, 98.26 deg.

COSMOS 1540 1984-22A, 14783

Launched: 0355, 2 Mar 1984 from Tyuratam by D-1-E.
Spacecraft data: Probably similar to Raduga 14.
Mission: Experimental communications relay, possibly related to the development of the 'Luch' satellite series.
Orbit: Geosynchronous above 80 deg east longitude.

INTELSAT 5 (F8) 1984-23A, 14786

Launched: 0050, 5 Mar 1984 from Kourou by Ariane (V8).
Spacecraft data: Box-shaped body, 1.66 x 2.01 x 1.77 m, with attached 4 m aerial mast. The span across the solar panels is 15.9 m and the mass in geosynchronous orbit is 1072 kg.

COSMOS 1541 1984-24A, 14790

Launched: 1712, 6 Mar 1984 from Plesetsk by A-2-e.
Spacecraft data: Possibly similar to the Molniya satellites and consisting of a cylindrical body surmounted by a conical motor section and drawing power from a 'windmill' of six solar panels.
Mission: Missile early warning satellite.
Orbit: Initially 592 x 39400 km, 710.43 min, 62.92 deg, and later raised to 706 x 39650 km, 717.78 min, 62.92 deg to ensure daily ground track repeats.

UPDATE: China 14 (1984-8A) was apparently a successful test of an apogee boost motor system for placing payloads into geosynchronous orbit.

The orbit of Cosmos 1535 (1984-10A) was 956 x 1017 km, 104.89 min,

BOOK NOTICES

Realm of the Long Eyes
J.E. Kloeppel, Univelt, Inc., P.O. 8ox 28130, San Diego, California 92128, U.S.A. 1982, 135pp, $15.

This brief history of Kitt Peak National Observatory emphasises the importance of the development of a new American national observatory in the eyes of many competent astronomers who did not otherwise have access to first-class instruments. The author relates how a group of astronomers from major observatories got the national observatory started. Once the decision to build was made, the process of selecting the site, negotiating land procurement with the Papago Indians (who considered Kitt Peak mountain to be sacred) was initiated. Access roads and other facilities were constructed.

The author then describes in detail the work carried out in constructing the major telescopes e.g. the 84 inch telescope, the McMath Solar telescope and the Nicholas U. Mayall telescope, together with their housings. The involvement of Kitt Peak in the US space programme, also, is not overlooked.

The observatory, nestling among the pines in the Quinlan Mountains of southwestern Arizona, houses the largest concentration of optical telescopes and astronomical instruments to be found anywhere in the world. Each year, hundreds of astronomers use the Kitt Peak telescopes to attempt to unlock the mysteries of the universe. Additionally, nearly a hundred thousand tourists visit Kitt Peak annually and, as a bonus, can enjoy the magnificent views across hundreds of miles of Arizona's rugged landscape.

The book includes numerous photographs and drawings showing all these facilities, instruments and housings and give an idea of the immensity of this major astronomical research facility. Examples of some of the photographs taken by the telescopes have also been included.

The Solar System
8.W. Jones, Pergamon Press Ltd., Headington Hill Hall, Oxford OX3 08W, 336pp, 1984, £11.75.

This book, presenting a contemporary picture of the Solar System, is pitched at an introductory level and thus assumes no previous knowledge of planetary astronomy. The aim is to highlight areas of agreement, disagreement and ignorance in astronomy with little use of mathematics beyond simple arithmetic. A multi-disciplinary approach is taken, involving physical, chemical, geological and biological aspects of planetary astronomy. Other important features are the inclusion of the results of all space-missions and Earth-based observations up to early 1982 and rather more on planetary interiors and the origin of planetary systems than is usual in a work of this type. There are questions at the end of each chapter and an extensive index.

The book provides a text much needed in the UK for introductory level courses at colleges and universities, as well as for upper school libraries. It will also be of considerable interest to the amateur astronomer and to scientists working in areas other than astronomy.

The Early Years of Radio Astronomy
Ed. by W.T. Sullivan,III, Cambridge University Press, The Pitt Building, Trumpington Street, Cambridge C82 1RP, 421pp, 1984.

Such is the pace of progress nowadays that history seems to emerge overnight. The story of radio astronomy is a good example. What happened yesterday is now of absorbing interest to generations with no idea of the early days and little concept of how it began or developed.

Radio astronomy began when Karl Jansky accidently discovered that the Milky Way was a copious source of radio waves. This, unquestionably, turned out to be one of the key developments in astronomy in our century. After the discovery of radio galaxies, quasars, pulsars, cosmic background radiation etc, the Universe was never the same place again. Besides that, the new style of research changed the way, perhaps even the attitudes, of some traditional astronomers, with a knowledge of electronics providing better chance of success than a primary training in astronomy. Added to all this was the fact that radio astronomy provided much of the incentive to scan the skies in every electromagnetic frequency possible, a concept which has dominated observational astronomy ever since.

Thus, after 50 years, this book collects the reflections of many of the radio astronomy pioneers, with a score of participants contributing their recollections and analyses of how, the field developed. True, although recollections are not history, these articles provide invaluable glimpses of the spirit of the times.

The present work is divided into five main areas. The first three sections deal with the formative years and with developments in Australia and England, respectively. For good measure the fourth section is devoted to the rest of the world. The final section considers the impact of radio astronomy on some of the other important areas of science.

Materials Processing in Space
Ed. 8.J. Dunbar, The American Ceramic Society, Inc., 65 Ceramic Drive, Columbus, Ohio 43214, USA., 343pp, 1983, £45.

This is the fifth volume in a series on "Advances in Ceramics." It was published in cooperation with NASA and ESA and coincides with heightened interest in space exploration following the successful space Shuttle flights and President Reagan's support for a US space station.

The volume provides an in-depth review of programmes and goals, materials and research techniques, the inter-relationship of diverse scientific disciplines and a myriad other aspects of materials processing in space.

Subjects covered include glass processing and glass melting in a microgravity environment, containerless processing, bubble behaviour, semi-conductor crystal growth and reviews of past, present and some projected future tests and proposed experiments to be conducted in the space environment.

All this falls within 17 chapters split in to three sections i.e. an international review of materials processing in space, materials processing in a microgravity environment and industrial and university applications and involvement.

The last five chapters of these are reprints, in their entirety, from "Challenges and Prospectives of Microgravity Research in Space" previously published by the European Space Agency.

Space Exploitation
Tim Furniss, 8atsford Academic and Educational Ltd., 4 Fitzhardinge St, London, 71pp, 1984, £6.95.

This slim volume is aimed at the lay reader who might ask, "Why should we waste money on space?" The author, a Society Fellow, provides a simple selection of facts and figures to show that it *is* a worthwhile effort. Several chapters cover the big moneyspinners of today: communications and Earth resources. Medicine, military reconnaissance and scientific exploration are included.

The book is an educational tool designed to inform although more detailed information will have to be found elsewhere.

A common error occurs on p.8 where the terms 'synchronous' and 'geostationary' are used synonomously; the latter is actually a special case of the former. Satellites can be synchronous without being geostationary.

Most of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

The Origin and Evolution of Planetary Atmospheres
A. Henderson-Sellers, Adam Hilger Ltd., Techno House, Redcliffe Way, Bristol BS1 6NZ, 1983, 236pp, £19.50

This is a fascinating survey of our current understanding of atmospheric evolution within the Solar System, reconstructing how very different atmospheres have developed from essentially the same ingredients.

The evolution of a planet and that of its atmosphere are intimately linked by the continuous physical and chemical interactions between them, so the observation of an atmosphere, coupled with an understanding of its evolutionary history, therefore offers a valuable insight into the history of the planet itself. This volume summarises the vast amount of new information gathered over the past two decades from the direct observation of planetary atmospheres.

The opening chapters describe the origin of the Sun, the Solar System bodies and the mechanisms which control atmospheric structure and characteristics during the evolutionary process. It then dicusses the primary evolutionary histories of the planets and their major satellites, tracing that of the Earth's atmosphere with particular reference to the origin and evolution of life, including a review of shorter term 'climatological' changes.

The Solar Granulation
R.J. Bray, R.E. Loughead & C.J. Durrant, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 2RU, 1984, 256pp, £27.50.

This book presents a comprehensive account of observational and theoretical knowledge of the solar granulation. The surface of the Sun, when examined with a sufficiently powerful telescope, reveals an irregular cellular pattern of polygonal bright element - *granules* - separated by narrow dark lines. Over the whole Sun there are some four million granules, whose average diameter is only about 1000 km.

Over the last 25 years the application of high-resolution observing techniques, both from the ground and from high altitude balloons, has provided a detailed picture of the properties and mode of origin of solar granulation. Since the first edition of this book appeared in 1967 the pace has quickened yet further. Granule observations of higher resolution have been obtained and powerful computers are opening the way to realistic numerical simulations of the complex hydrodynamic processes involved.

Stars covering a wide range of spectral class also possess convective envelopes and, therefore, must display similar granulation-type phenomena. Direct observations of stellar granulation is not feasible, but the authors discuss indirect diagnostics of stellar convection which have recently been introduced.

Granulation is basically a convective phenomenon, each granule and its surrounding dark material representing a single convection cell. A feature of this new edition is an extended discussion of the theory of convection, emphasizing astrophysical convection but including, where relevant, the theory and results of laboratory experiments. The authors take pains to make this complex branch of fluid dynamics accessible to the non-specialist.

Maxwell on Saturn's Rings
Ed. S.G. Brush, *et al*, MIT Press, 126 Buckingham Palace Road, London SW1W 9SD, 199pp, 1984, £22.50

Since being first sighted dimly through Galileo's telescope and up to the recent spectacular pictures beamed back by Voyager, Saturn's rings have fascinated generations of observers both with their mystery and beauty. The scientific problems associated with them have also attracted the attention of generations of theorists. Of these, particularly outstanding was James Clark Maxwell's 1856 essay 'On the Stability of the Motion of Saturn's Rings' which forms the central core of this book. The Adams Prize Essay had been instituted to honour John Couch Adams who had predicted, mathematically, the existence of the planet Neptune and was awarded every two years for the best essay on some subject of pure mathematics or astronomy.

Maxwell's essay was the work which established his reputation as a great mathematical physicist. Included, too, is much previously unpublished material written both before and after the essay was compiled. This shows him working out the problems, so revealing the sureness of his approach as well as false starts and errors, besides attempting to extend his analysis to include the effects of collisions among the particles of the ring, to which end he employed his newly-developed kenetic theory of gases.

Although there is much of considerable interest to the general reader in this work, most of the text is neccessarily of a mathematical character. One fascinating sidelight in all this is that Saturn was first noted to have a curious shape by Galileo, in 1610. He announced his discovery in a letter to Kepler in the form of an anagram which was meant to read 'I have observed the most distant of planets to have a triple form.' As it happened, Kepler misread the message to read 'Hail, twin companionship, children of Mars' which seems to have been a source of the belief that Mars had two satellites, eventually given literary form by Jonathan Swift in *Gulliver's Travels* in 1726 and finally shown to be true by Asaph Hall in 1877!

Quantum fields in Curved Space
N.D. Birrell & P.C.W. Davies, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 2RU., 140pp, 1984, £13.75.

The subject of quantum field theory in curved spacetime, as an approximation to an as yet inaccessible theory of quantum gravity, has grown tremendously in importance during the last decade so a volume which attempts to collect and unify the vast literature contributing to this development is to be welcomed.

All the major technical results are presented and the theory developed carefully from first principles. Although the treatment is general, special emphasis is given to the Hawking black hole evaporation effect and to particle creation processes in the early Universe.

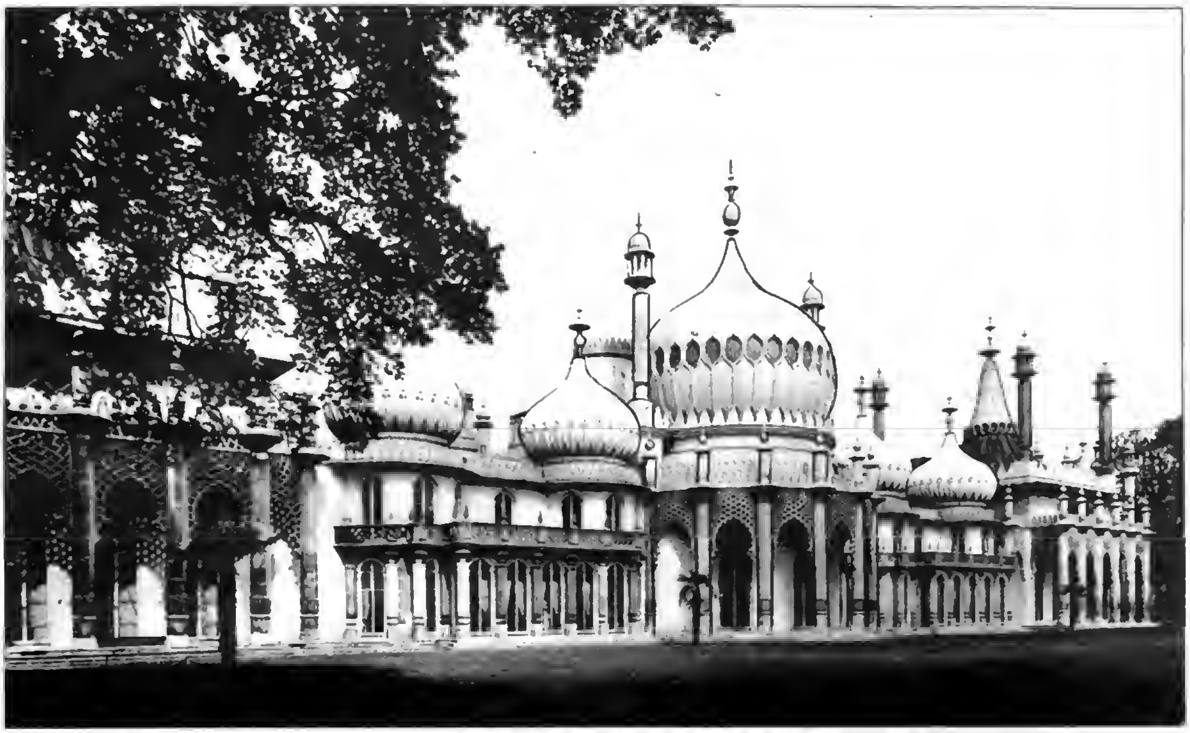
It contains everything that students or researchers will need to embark upon calculations involving quantum effects of gravity at the so-called one-loop approximation level.

Landolt-Bornstein Group V, Vol 2 Geophysics of the Solid Earth, the Moon and the Planets (Sub volume a)
Springer-Verlag GmbH, Heidelberger Platz 3, Postfach, D-1000 Berlin 33, 417pp, 1984, $283.30.

Members will know from reviews of previous volumes in this series that this is solid fare. Group V is concerned with Geophysics and Space Research and consists of four volumes, two of which are sub-divided into sub-volumes a and b i.e. making six individual books in all.

As might be expected, the main bulk of this work concerns data relating to the Earth, with that for other planets minimal by comparison. The Earth as a planet poses many more problems than are first appreciated. Although geophysics is a science which operates on an international basis (physical properties of the Earth as a solid body can only be evaluated from a global point of view) the acquisition of such data and its interpretation are subject to regional influences. The Editors admit that they are still far away from a world-wide standard for all such measurements and interpretation procedures and, therefore, have thought it necessary to open with a detailed discussion of the measuring interpretation methods before the actual data itself, to give the reader a chance to use this information properly. In some cases it was also so necessary to discuss in detail the premises, as well as the boundary and initial conditions, without which it would have been difficult to judge the reliability of the data. Part of these premises are themselves disputed e.g. the problem of temperature distribution in the Earth's interior. Here, considerable differences emerge, depending on whether an initially cold or hot Earth is assumed and on the distribution and concentration of the isotopes generating radiogenic heat during the Earth's history.

The Editors and their contributors have tried to collect together as much as possible of all the representative data and information. For many of the areas dealt with, considerable improvements of detail are expected over the next few years.



The Brighton Pavilion will be included on a special Ladies' Programme being organised for Space '84.

The Society will once more be using Brighton as its Space venue because of the excellent Conference facilities. Brighton has been on its toes to cater for conference business for many years now and has grown to one of Europe's largest centres during the past decade. Our venue, The Brighton Centre, opened in 1977. It is a multi-purpose building packed with specialist features which make it indispensible for large meetings such as Space '84. We will be using the Foyer Hall, as for Space '82, which everyone found so satisfactory and with the huge Main Hall, once again, reserved for the Banquet.

The Foyer Hall seats up to 800 people although we want to keep numbers down to about half that, so that everyone has plenty of room (plus exhibits, etc.). The Main Hall – if we needed it at some future time – provides a 5000 seat capacity with translation and TV/radio facilities also available and with many smaller 'seminar' rooms to hand.

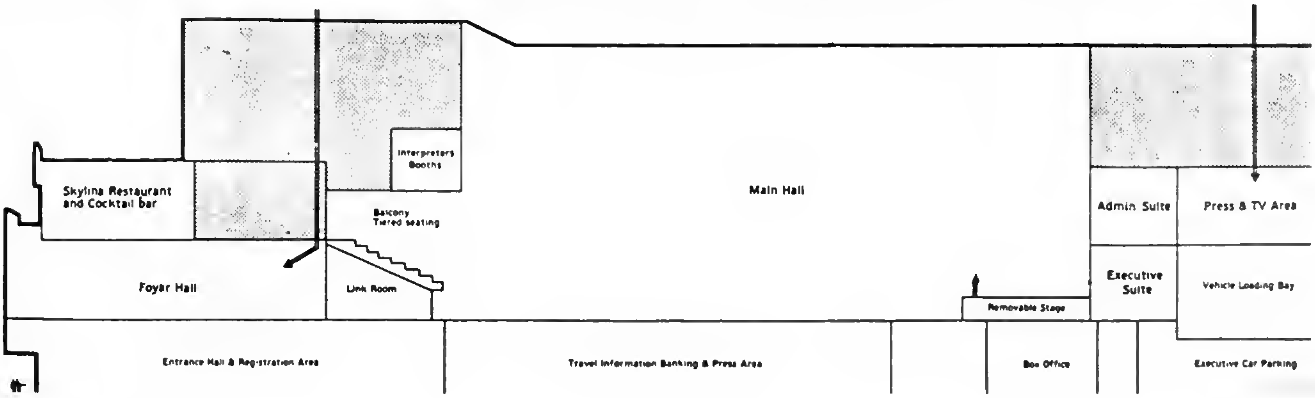
Brighton is easy to reach. Gatwick airport – with links to 125 cities around the world – is only 30 minutes away, with the M23 connecting to Brighton on one hand and London on the other. Accommodation, ample and varied, ranges from the small guest houses to the first class hotels. A large selection of theatres, restaurants and clubs ensures there is plenty of night-time activity.

There is always plenty to see during the breaks at Space '84. The most famous of all Brighton's attractions is surely the Royal Pavilion, completed in 1822 by the Prince Regent. This is one of the stops of the Space '84 ladies programme (more details will be available later). Just a minute's walk away are the 'Lanes,' in the traditional heart of Old Brighton. Theses are a tangle of small by-ways filled with antique shops, pubs and restaurants.

16-18 November 1984

SPACE '84

Below: A schematic of the Brighton Centre. The dimensions have been distorted to squeeze several floors on to one diagram.



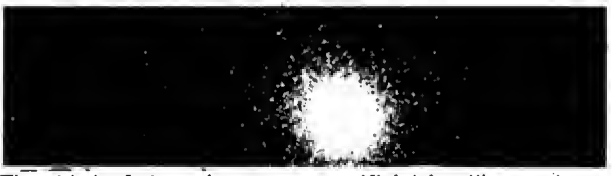
spaceflight

Correspondence, manuscripts intended for publication and requests for information on membership may be addressed to the Executive Secretary at the Society's Offices at 27/29 South Lambeth Rd., London SW8 1SZ. Tel: 01-735 3160.

NOTICES OF MEETINGS

Full details on some of the meetings listed below are to be found inside the magazine.

Lecture
Title: **APPLICATIONS OF ARTIFICIAL INTELLIGENCE TO SETI AND CETI**
by Tim Grant



The third of three lectures on artificial intelligence in space exploration. This lecture considers applications to the search for (and communication with) Extra-Terrestrial Intelligence and their artifacts.

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London, SW8 1SZ on **27 June 1984,** 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

39th Annual General Meeting

The 39th Annual General Meeting of the Society will be held in the Alliance Hall, Palmer Street (next door to Caxton Hall), London, SW1 on Saturday **22 September 1984,** 3.00 p.m.

Details of the Agenda will appear in *Spaceflight* in due course.

Council nomination forms can be obtained from the Executive Secretary. These must be completed and returned not later than **29 June 1984.**

If the number of nominations exceeds the number of vacancies, election will be by postal ballot. Voting papers will then be prepared and circulated to all members.

35th IAF Congress

The 35th Congress of the International Astronautical Federation will be held in Lausanne, Switzerland on **7–13 October 1984.**

Theme: **SPACE BENEFITS FOR ALL NATIONS**

Members of the Society wishing to present papers are asked to notify Dr. L.R. Shepherd, Chairman of the BIS International Liaison Committee at Society HQ as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

Space '84

The Space '84 "weekend" will be held in Brighton on **16–18 November 1984.** See inside this issue for details.

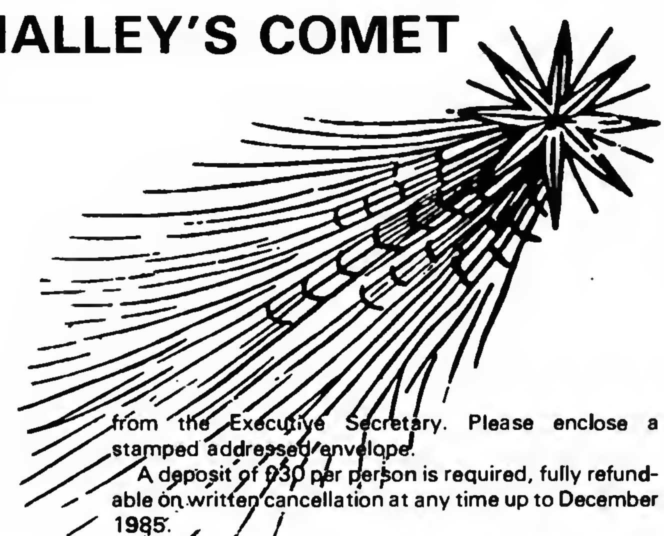
LIBRARY

The Library will be open to members from 5.30 to 7 p.m. on the following dates:

16 May   30 May
6 Jun

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

RENDEZVOUS WITH HALLEY'S COMET



Owing to the likelihood that Halley's Comet will prove to be a disappointing object when viewed from the Northern Hemisphere, if it can be seen at all, the Society plans to organise a trip to South Africa to view the comet from the Southern Hemisphere. Present indications are that the most favourable time will be the first week in April 1986. The provisional itinerary is: flight from London to Johannesburg, four nights in Johannesburg, three day tour of Kruger National Park, flight to Port Elizabeth, three day tour of the Garden Route from Port Elizabeth to Cape Town, four nights in Cape Town, and return to London *via* Johannesburg. There will be plenty of opportunities for viewing the comet.

The approximate cost at present day prices is £1,000. This includes all air and coach travel, accommodation in first class hotels, plus breakfast and dinner on coach-travelling days.

Forms for provisional registration are now available from the Executive Secretary. Please enclose a stamped addressed envelope.

A deposit of £30 per person is required, fully refundable on written cancellation at any time up to December 1985.

Halley's Comet – April 1986 – 14 days duration

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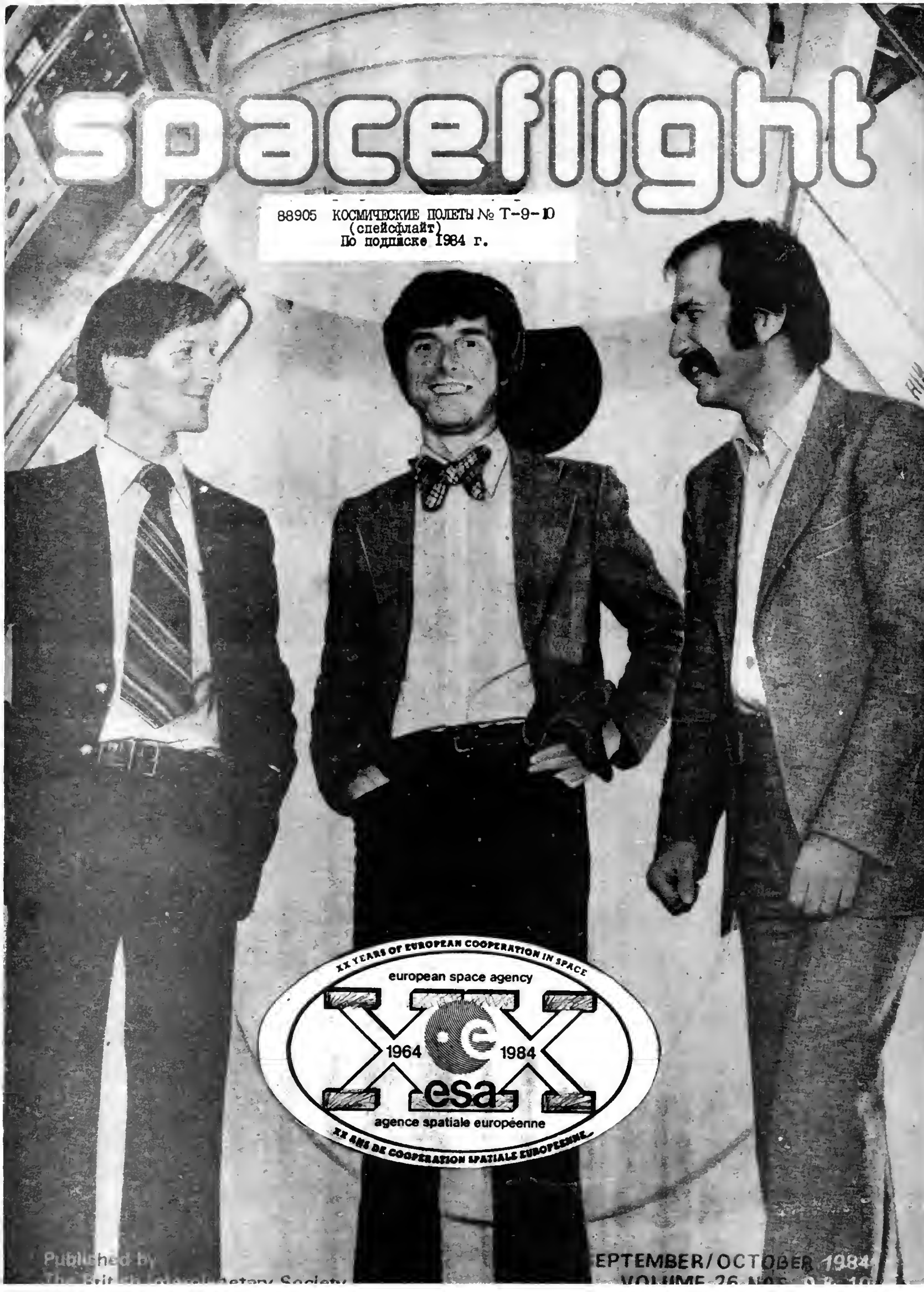
spaceflight
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(спейсфлайт)
По подписке 1984 г.
XX YEARS OF EUROPEAN COOPERATION IN SPACE
european space agency
1964
1984
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agence spatiale européenne
XX ANS DE COOPERATION SPATIALE EUROPEENNE
Published by
SEPTEMBER/OCTOBER 1984

SPACE '84

16-18 November 1984

SPACE — THE FUTURE OF MANKIND

Our programme for Space '84 at the Brighton Centre introduces a wide variety of space experts covering a wide range of space subjects.

The meeting will be divided into sessions on: New Frontiers, Discovering the Universe, Foothold in Space, Energy and Resources, Advancing Frontiers, the Future of Mankind and Workshop.

The preliminary programme is as follows:

Dr. G. E. Mueller	:	Space: The Future of Mankind
Dr. A. R. Martin	:	Space Resources and the Limits to Growth
Prof. M. Rees	:	Space Astronomy
Dr. J. K. Davies	:	New Eyes in Space
Dr. W. I. McLaughlin	:	The Philosophy of Extra-terrestrial Intelligence
D. L. Pivirotto	:	Space Platforms and Autonomy
I. Bekey	:	Space Tethers
J. L. Blonstein	:	Steps to Space
Dr. D. J. Shapland	:	Spacelab — A Laboratory for the Future
Dr. J. T. Houghton	:	Remote Sensing of the Oceans
C. Honvault	:	Operational Meteosat
J. Casani	:	Project Galileo
R. P. Laeser	:	Voyager: Now Through Neptune
K. Gallagher	:	Time and the Space Ships
R. M. Jenkins, D. C. R. Link and J. Simpson	:	Giotto Update
Dr. G. Haskell	:	Asteroid Probe
G. P. Whitcomb	:	Future Missions for the ESA Science Programme
S/L R. M. Harding	:	Space: Human Physical and Mental Adaptability
Dr. R. C. Parkinson	:	The Prospects for Colonising Space
A. T. Lawton and Penny Wright	:	Monopoly: A Monopole Motor for Interstellar Propulsion
R. Gibson	:	European Involvement in Space Station Development
R. J. H. Barnes	:	European Space Autonomy & Cooperation with NASA: An American View
Dr. H. Joyce	:	Space Radar Systems

Ladies Programme

Two special Ladies Programme excursions have been arranged for Space '84. On Saturday, 17 November, there will be a private tour, with coffee, of the historic Royal Pavilion in Brighton itself, Sunday, 18 November, will see an all-day tour by luxury coach through the Sussex countryside, including a visit to the House of Pipes (for coffee) and lunch at Barnsgate Manor Vineyard, tour of the vineyard, wine-tasting, etc.

Further details on both events are available from the Executive Secretary. Early booking is essential.

Civic Reception and Banquet

A Civic Reception (dance/supper) by courtesy of the Brighton Corporation will be held in the Brighton Centre on the Friday evening to give everyone an opportunity to meet before the conference proper begins.

Highlighting Saturday's social activities will be a Banquet with Guest Speakers Sir Peter Masefield, Ted Mallet and Patrick Moore. The aperitif, 4-course meal and half bottle of wine per person will be provided at a cost of £18.00 per ticket.

To keep the friendly atmosphere of Space '82, the number of places available will be held down to 400. Simply fill out the form below and send it to the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ.

SOUVENIRS OF THE OCCASION

Space '84 souvenirs will take the form of commemorative mugs and decanters all embossed with the Society's motif, with the Space '84 logo added for those who would like this too.

Several types are available: pint sized tankards at £10, and half-pint tankards at £6. Special silver-handled half-pint tankards in presentation boxes are available at £7.50. Decanters at £25 are also available.

Please forward a registration form and details on Space '84. I enclose a 20p stamp.

Name: . . . .

Address: . . . .

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spaceflight

A Publication of The British Interplanetary Society

Founded 1933 *Incorporated 1945*

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CONTENTS

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A THIRD COMMUNITY IN SPACE

Man's venture into space is still dominated by the efforts and enterprise of two great nations, the USA and USSR. They alone have the capacity for manned space flight and the immediate capability of pressing forward to the next stages of the conquest of space and the exploitation of extraterrestrial resources. Yet they comprise only 11% of the human population, the great remainder being well and truly Earthbound.

Mankind is now more than a quarter of a century into the space age. The time has surely come when we should strive for a broader participation in activity at the space frontier. The present restricted membership of the space club is neither healthy nor desirable for humanity as a whole. It is a simple axiom that Space encompasses the Earth and, consequently, that those occupying Space effectively surround those who are Earthbound. The military implications of this cannot be overlooked. If we are to avoid the development of space into a military theatre then we must ensure that it becomes, predominently, an economic arena. That would not eliminate the military presence in space but it would make it less obtrusive. Space activity, thereby, would be concerned much more with trade and industry than with martial conflict.

The development of a thriving space economy must depend upon the widest possible participation of the global human community. This cannot happen overnight and we must look first to the prospect of establishing, as quickly as possible, a "third community" in space, to be followed by others, that will be able to compete and collaborate on an equal footing with the two communities already established there.

Space technology, of course, is already actively pursued by many countries, though on nothing like the scale reached by the two front runners. There are, nevertheless, some solid foundations upon which further powerful space efforts could be built. The most advanced base is provided by those European countries who already collaborate in ESA, so it is reasonable to look to this grouping for leadership in establishing a third space community to rival the USA and USSR. This could be further strengthened by adding other partners, one particularly powerful combination being offered by a joint enterprise with Japan.

It is instructive to examine the potential of the ESA-participating countries in the light of their collective Gross Domestic Products and the overall resources that they devote to research and development of all kinds.

Continued overpage

COVER

The European Space Agency this year celebrates 20 years of space cooperation within Europe. The Spacelab 1 mission late last year saw the culmination of years of effort when Ulf Merbold (centre) flew as the ESA payload specialist aboard the European laboratory. Wubbo Ockels (right) was his backup. Claude Nicollier (left) will fly as a mission specialist aboard the Shuttle in November 1985 with some of the Spacelab 1 experiments. *ESA*

 В журнале не печатается ряд страниц.

TABLE: Gross Domestic Products and R&D Expenditure 1983.

	ESA Countries	Japan	USA
GDP Gigadollars	2740	1160	3300
R&D Gigadollars	55	29	90

The table gives the financial statistics in question for the year 1983 for the ESA Countries, Japan and, for comparison, the USA. The figures are in Gigadollars, i.e. USA $Billion, at current rates of exchange.

Of the total R&D expenditure of the ESA countries, 70% is accounted for by three only i.e. W. Germany (30%), France (20%) and the UK (20%). On average the countries in ESA devoted 2% of their GDP to R&D, compared with 2.7% in the USA and 2.5% in Japan. Where expenditure on space activity is involved, however, a large gap emerges between the USA and European priorities. Only about 2.5% of the R&D budgets of the ESA countries found its way into space, compared with 7% of the USA R&D funds that were allocated to NASA. If the countries in the European group raised their space priority to the American level, they would devote $4000 Million per annum (in 1983 terms) to space technology. Nothing less than this will be likely to keep Europe near to the front of the running as we move towards the next century. Indeed, to close the gap that presently exists between Europe and the USA the annual space expenditure of the European group might well need to be 50% higher than the figure just specified. One way of achieving the extra funding might be to enter into a wider partnership including Japan and other countries prepared to devote the same level of priority to space in their budgets.

If the European group is to form the nucleus of a third space community then it will have to raise the priority that it gives to space technology to the extent indicated. In fact, one member of the group, France, already comes close to the necessary level of funding in its space budget. It is really a matter of the others following the French example and then for the whole group to improve upon the resulting performance at a modest rate.

Forming a competitive force in space is not just a matter of how much money is spent, but *how* it is spent. It can be argued that the space research programme of ESA together with the corresponding individual national activities already amounts to a significant contribution when judged against those of the USA and USSR, though they fall short in the matter of interplanetary exploration. Moreover, in the more mundane, but nonetheless important, applications such as communications, the requirements are fairly well served. It is not in these areas that a substantial boost is required.

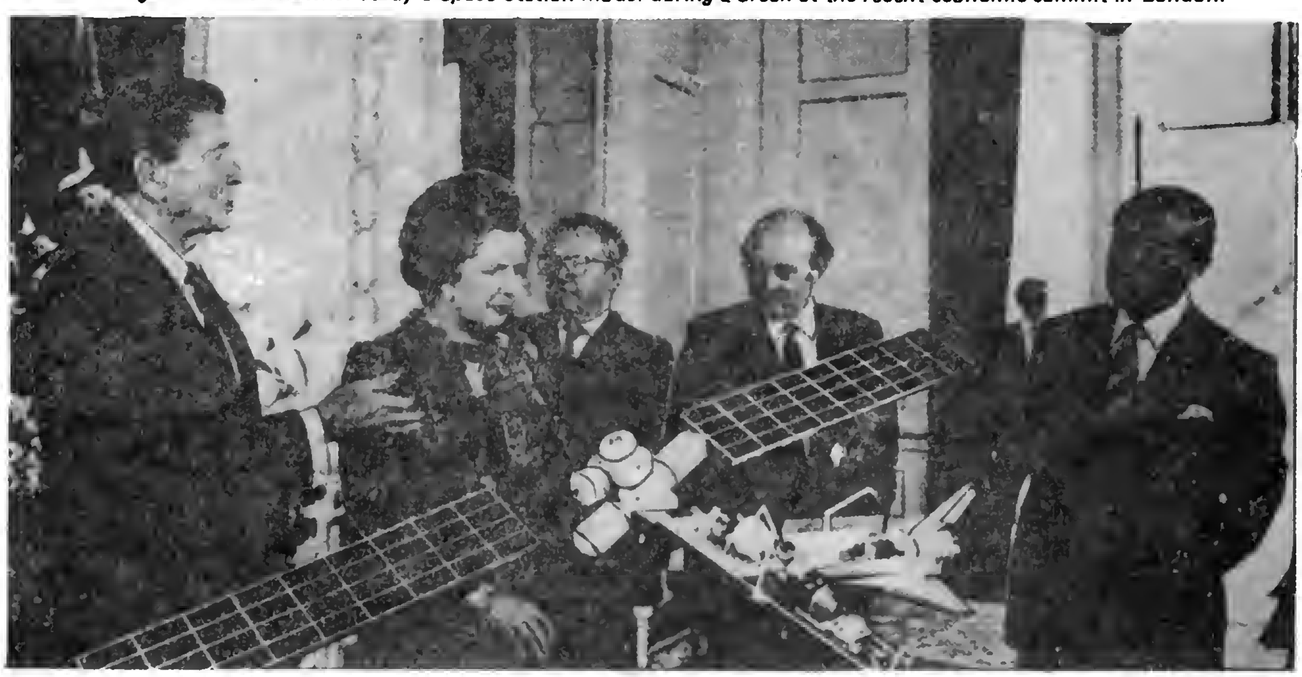
Western Europe has no manned space flight capability nor is it moving towards one in the foreseeable future. Related to this situation is its lack of any serious plans for the developments of a space transportation system that will be relevant to the requirements of the turn of the century. Relatively small expendable launchers, such as Ariane, are strictly limited in their applications. In this respect W. Europe lost ten years when it abandoned the Europa launcher and it may have lost the same amount of ground in proceeding to the next stage of launch vehicle development.

We believe that the highest priority must be given to playing a major role in developing a second generation recoverable orbital vehicle. The success of NASA's Shuttle clearly demonstrates the way ahead. This, almost certainly, would not be an enterprise to be approached single-handed, but it might well form the basis for a joint venture, for example with NASA, ensuring the European partners the full rights to build and use the resulting product for their own purposes.

There are other forward-looking developments that should demand attention in a much expanded European space programme. One that deserves mention here would be the next significant step in the economic exploitation of space, namely the establishment of major orbital facilities or space stations. Lacking an adequate independent transportation system, the European group will not be in a position to play a major role in the initial stages of space station development but it should not scorn a junior partnership in such an enterprise.

The need for a third community in space is overwhelming. ESA partners possess the wealth and resources to provide the nucleus for such a community. Do they possess the vision and enterprise?

President Reagan and Mrs Thatcher study a Space Station model during a break at the recent economic summit in London.



CONGRATULATIONS TO ESA

Our Society's President, Tony Lawton, and Executive Secretary, Len Carter, were among 600 invited guests attending the 20th Anniversary celebrations of the European Space Agency last May at ESTEC in Noordwijk, The Netherlands.

Introduction

The European Space Agency (ESA) originated from the merger of the European Space Research Organisation (ESRO) and the European Launcher Development Organisation (ELDO); both officially came into being in 1964 and thus this year marks the 20th year of European cooperation in space. Over that period the European space effort has resulted in the successful launch of 127 sounding rockets, 12 scientific spacecraft and five applications satellites; the European launcher Ariane has successfully launched seven payloads and Europe has entered the manned space field with the magnificent Spacelab 1 mission.

The highlight of the celebrations week was on Wednesday, 9 May. The morning took the form of a panel discussion and teleconference on the theme of "Europe in Space"in the ESTEC Test Hall.

This was linked by teleconference and video transmission facilities *via* the Eutelsat-1 F1 (ECS 1) satellite to ESA HQ in Paris, to ESOC (European Space Operations Centre) in Darmstadt, to ESRIN at Frascati, near Rome,as well as the Ariane launch base in Kourou, South America. The fact that Eutelsat was used and that the National Post and Telegraphs Adminstrations of many countries participated was an example of European space cooperation in itself, allowing press representatives and personalities assembled at the centres to take an active part in discussions.

The morning proceedings began with an ESA film that pointed out significant changes in the industrial activity which has hitherto been the source of all our wealth. For example, Meteosat provides weather information that may tip the balance between success and failure in farming and horticulture. Communications at sea, always difficult, are now being transformed – some thousand or so ships and aircraft possess satellite navigation capability today, out of a million or so potential customers. These figures underline the potential for communications services, already becoming more difficult to meet. Olympus, at 2400 kg, will be the first of a new generation of communications satellites created to meet an almost ceaseless demand for increased facilities.

Society President Tony Lawton (left) with Ted Mallet, ESA Director of Applications Programmes. Note the Giotto Halley's comet probe model in the background.

Particularly interesting was the discussion that concerned the possibility of European involvement in US Space Station proposals. ESA already has in mind an automatic instrument facility for unmanned operation which is really midway between Spacelab and a Space Station. Germany and Italy have offered their own designs for a manned space platform (Columbus) for launch by an improved version of Ariane, but all raise problems both of funding such expenditure and the effect on the allocation of total ESA resources. The clear impression is the need now for ESA member-states to get together to decide on their future objectives and thus enable ESA to move ahead confidently. As the celebrations coincided with a meeting of the ESA Council, one might hope that the opportunity was taken to study just these aspects, though it is hard to feel confident that this is the sort of thing which automatically happens. More likely, as Sir Peter Ansen, Managing Director of Marconi Space Systems Limited observed later, it is much easier in any international organisation to *stop* things from happening than to *make* them happen.

Professor H. Curien, Chairman of the ESA Council, strongly supported the development of space stations and added that it was imperative that these be developed for planetary missions as well. Regarding cost, he pointed out that if ESA created the impression that such projects were beyond its means, it would fail in its duty. It simply amounted to a much greater programme than had been envisaged up to now. The Netherlands' Minister of Transport and Public Works, Mrs. Neelie Smit-Kroes, was also very enthusiastic about space activities and the need for a positive European programme, while Dr. A. Caruso (Secretary-General of Eutelsat) added that, in his field, the time had now arrived for money to be given *back* to contributors rather than requesting more.

Sir Peter Ansen, expressed concern about the stop-go character of space arrangements. These resulted in a virtual tidal wave that moved through various departments of industry in turn, so the need for regular contracts was imperative. As regards space stations, the need was for Europe to get into the central core, not simply to be satisfied with "add-ons."

Current US proposals envisage that Europe should contribute 20% to the cost of the Space Station project but problems still to be resolved, from an European point of view, concerned not only what form this 20% contribution would take but what the real cost would amount to both in capital and subsequent running costs.

Afternoon Programme

The afternoon session was graced by the attendance of Her Majesty, Queen Beatrice of the Netherlands. A short introductory video presentation was made and a longer

20 YEARS OF EUROPEAN COOPERATION IN SPACE

1960: Signature by 12 European States of the "Meyrin" agreement setting up a preparatory commission for European Space Research (COPERS) - Austria, Belgium, Denmark, France, W. Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, UK.

1962: Signature by Belgium, France, W. Germany, Italy, the Netherlands, UK and Australia of the Covention setting up the European Launcher Development Organisation (ELDO). Signature of the ESRO (European Space Research Organisation) Convention by 10 States.

1964: The ELDO and ESRO Conventions came into force.

1966: First ESRO sounding rocket launched from Andoya (Norway). A Ministerial Conference decided that the initial ELDO programme, Europa I, should be replaced by the development of a heavier launcher, Europa II, capable of injecting 200 kg satellites into geostationary transfer orbit. ELDO decided to build its own launch range within the framework of the French Guiana Space Centre (CSG).

1966: Signature of a cooperation agreement with NASA for the launch of ESRO satellites. Esrange (Kiruna, Sweden), sounding rocket launching range, became operational.

1967: ESRO II was launched but did not reach its orbit due to a failure of the US Scout rocket. Inauguration of ESOC, Darmstadt, W. Germany; The ESRO satellite control centre was moved from ESTEC.

1968: ESTEC (Noordwijk, the Netherlands) was inaugurated. ESRO II (Iris), ESRO Ia (Aurorae), HEOS-1 and ESRO Ib (Boreas) were successfully launched.

1971: Failure of the Europa F11 firing led ELDO Member States to decide to discontinue both the Europa II development and the study of a heavier launcher, Europa III. The ESRO Council unanimously adopted a Resolution on the reform of ESRO, including in particular the development of applications satellites within the framework of ESRO.

1972: HEOS-2, TD-1A and ESRO-IV were successfully launched. The last ESRO Sounding Rocket Campaign took place at Andoya Range (Norway).

1973: Meeting of the European Space Conference in Brussels where general agreement was reached on an overall European space programme. One of the main items was the development of the Ariane launcher. The ESRO Council approved the Director General's recommendation that Europe should participate in the US post-Apollo programme by developing Spacelab. The Memorandum of Understanding with NASA was signed in September. Approval was given to undertake the Maritime Satellite Programme (Marots later to become Marecs).

1975: Plenipotentiaries Conference; ESA Convention signed by 10 Member States. The European Space Agency came "de facto" into being; Roy Gibson became first Director General on 16 April. Successful launch of COS-B (gamma ray astronomy satellite).

1976: Approval of ESA participation in the NASA Space Telescope project (solar arrays and faint object camera).

1977: Launch of GEOS-1. The satellite did not reach its planned orbit due to a US Delta launcher problem. It was, however, able to make a substantial contribution to the International Magnetosphere Study. Launch of ISEE-B, one of three spacecraft of a joint ESA-NASA project for the study of the magnetosphere and Sun-Earth relationships. Launch of Meteosat 1, Europe's contribution to the World Weather Watch Programme. The SLED experimental facility - originally to be flown on board the first Spacelab mission - was approved. The Orbital Test Satellite (OTS) was lost due to explosion of the US Delta launch vehicle. Agreement was reached on setting up Earthnet, a European network for the reception, pre-processing, distribution and archiving of data from remote sensing satellites.

1978: Launch of the second Flight Model of the Orbital Test Satellite (OTS 2). Launch of International Ultraviolet Observatory. Approval of the European Communications Satellite programme. Approval of a joint ESA/NASA project: ISPM (then known as Out-of-Ecliptic). Approval of the Sirio 2 programme.

1979: Preliminary approval for the large telecommunications satellite project (since re-named Olympus). Signature of the cooperative agreement between ESA and Interim Eutelsat for setting up of the space segment of the European Communications Satellite System (two spacecraft). Ariane: the first test flight was a total success (24 December).

1980: Two new scientific projects - Hipparcos and Giotto - were approved. The International Maritime Satellite Organisation, Inmarsat, signed contracts with ESA for the lease of Marecs-A and B as part of its global maritime communications satellite system. Signature of the NASA/ESA contract for the production of a second Spacelab in Europe, to be purchased by NASA. Ariane L02 was a failure due to a malfunction of a first stage engine. Development of two more powerful versions of the launcher - Ariane 2 and 3 - was approved. Arianespace, a private company responsible for manufacturing, marketing and launching Ariane after completion of the ESA-managed promotion series, was set up.

1981: Following two successful launches - L03 and L04 - Ariane was pronounced qualified. Construction of a second launch site, ELA-2, at Kourou was approved. ESA and NASA accepted the Spacelab Flight Unit which was delivered to NASA in December. The Spacelab Follow-on-Development Programme, including the defintion, development and operation of a retrievable carrier (Eureca) was approved. Following NASA's decision to abandon its part of the joint ISPM programme, it was agreed to proceed with a one-spacecraft mission.

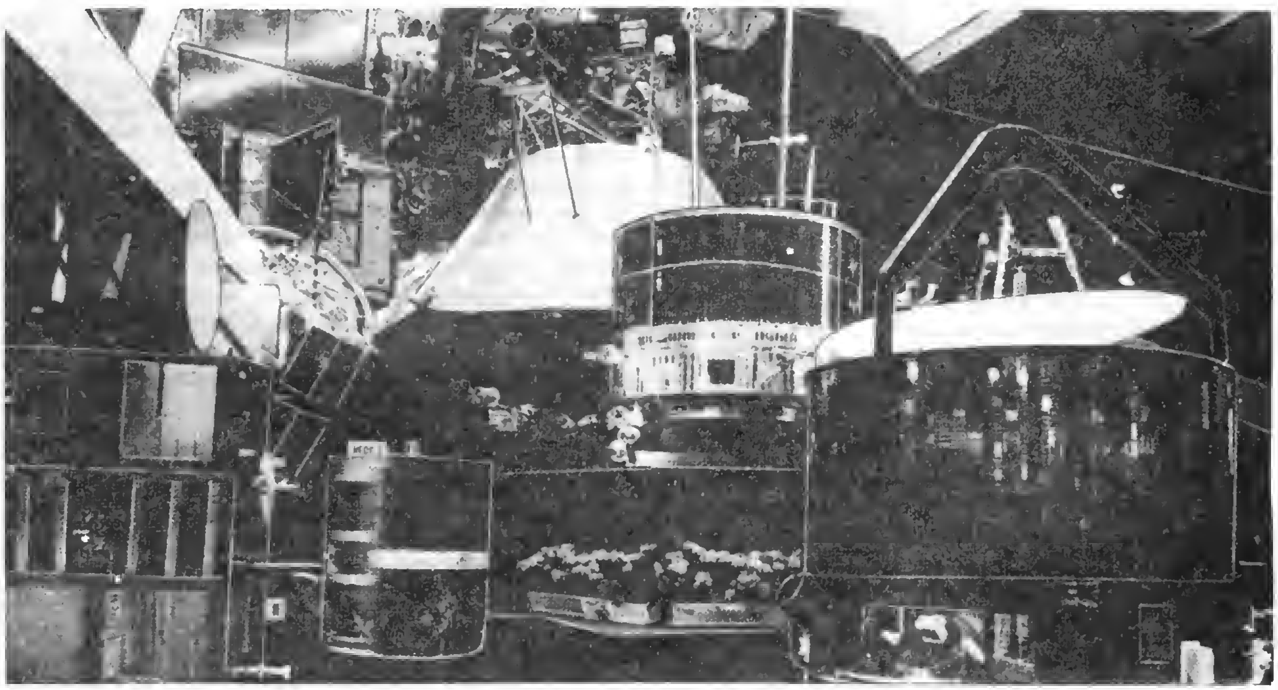
1981: The Microgravity Programme (covering Life Sciences and Material Sciences) was approved. Approval was given to proceed to the development phase of Olympus (L-Sat). General agreement was reached on the mission, payload and ground support concept of the ESA Remote Sensing Satellite Programme, ERS-1.

1982: Marecs B and Sirio 2 were lost due to the failure of Ariane L5. The Ariane 4 development programme was approved. The Spacelab Follow-on-Development and the Microgravity Research programmes, approved in 1981, got underway.

1983: The first Spacelab mission was a total success. ECS 1 was successfully launched by Ariane L6. Intelsat V F7 was successfully launched by Ariane L7. Exosat was successfully launched by a US Delta. The operational Meteosat Programme was approved and the Convention establishing Eumetsat was signed by 13 European States. The Infrared Space Observatory, ISO, was selected as ESA's next scientific project.

1984: Intelsat V F8 was successfully launched by Ariane V8. ESA celebrates 20 years of European cooperation in space.

Above: ESA/Spacelab 1 astronaut Ulf Merbold describes his flight to Her Majesty Queen Beatrice of The Netherlands. *Below:* an array of models representing 20 years - and beyond - of European involvement in space. *From left:* Seasat, Heos 2, Exosat, Esro IV, International Solar Polar Mission, Geos and Giotto. *ESTEC/ESA*



film on Spacelab 1 highlights with commentary by European astronauts Ulf Merbold, Wubbo Ockels and Claude Nicollier was included, together with four papers reviewing past ESA work. The first,by Professor de Jager, President of COSPAR, described the scientific programme that had hitherto been the cornerstone of European space activities, though increasing interest was now being shown in an applications programme. This was followed by two appraisals on a similar theme, one by Sir Herman Bondi and the second by Mr. Harris, the Belgian Minister of Science Policy, and concluded by a view on Europe's space future given by its current Director-General, Eric Quistgaard.

Mr. Quistgaard pointed out that the main aims of ESA are to provide and promote cooperation between European states in space research, technology and applications and also to elaborate and implement a longer-term European space policy programme. Its basic activities include a programme of scientific satellites with telecommunications, Earth observation and space transportation systems as optional extensions. Finance comes from its 11 member states which contribute on the basis of gross national product to the scientific programme and on an "optional agreement" to other programmes. ESA currently has a total staff of 1350 drawn from the member states. This includes about 800 engineers and technicians and 100 scientific personnel.

A breakdown of its budget for 1984 is as follows:

	%
Telecommunications	26.0
Earth Observation	17.6
Spacelab ,	12.8
Ariane	17.1
Scientific	12.7
General 8udget	13.8

Approximately 13% of the budget comes from the UK, with France providing 22.6% and Germany 19.9%. Italy comes fourth with 12.4%.

ESTEC is ESA's largest establishment, responsible for the study, design, development and testing of components and complete space vehicles for both research and applications. Some of the projects currently under development are:

Space Telescope
Joint NASA/ESA programme to orbit a telescope with a main mirror diameter of 2.4 m (1986 launch, Shuttle).

ISPM – International Solar Polar Mission
Joint ESA/NASA programme with one ESA satellite to study the polar region of the Sun and the Solar System from an out-of-ecliptic orbit (1986 launch, Shuttle).

SLED
Spacelab life science experiments (1985 launch, Shuttle).

Giotto
Halley's comet fly-by (mid 1985 launch, Ariane).

Hipparcos
Measurements of astrometric parameters of stars (1988 launch, Ariane).

ISO
Infrared Space Observatory (1990 launch, Ariane).

Some of the scientific projects now being studied are:

AGORA	Mission to the asteroids
Cluster	Plasma physics in the Earth's magnetosphere
SOHO	Solar research
First	Infrared astronomy
XMM	X-ray astronomy

Exhibits

A superb range of exhibits filled the area adjacent to the Conference Room. This was not an exhibition arranged overnight nor one consisting of the fortuitous arrangement of hardware currently to hand. It was the result of considerable thought and planning over many months. At one end was a full size cutaway of an Ariane payload shroud, showing a satellite inside and giving a most impressive view of its size. At the far end was a group of satellites arranged in an ascending order and reminiscent of the splendours of a cathedral. Filling the area between were satellites and hardware of such interest that practically everyone attending must have spent several hours looking at the items displayed.

Celebration Banquet

The climax of the day's events was a banquet in the Ridderzaal (Knights' Hall) in the Hague, attended not only by the full ESA Council and senior ESA officials but also by many other distinguished representatives from government, industry and major space concerns. The Ridderzaal was not only a most beautiful building, incorporating the Royal Throne, but in such company and with music provided by a Ladies String Orchestra, the event was one long to be remembered

ESA Director-General Erik Quistgaard (left) and ESA astronaut Claude Nicollier, who fly aboard the Shuttle next year (see cover photograph).

ESTEC Staff Celebrations

Not to be outdone, the ESTEC staff themselves had arranged a number of events. Foremost was the Victorian Evening on 10 May, produced largely as a result of the labours of Norman Longdon who took the trouble to grow sideboards specially for the occasion (the moustache wasn't real) and acted as Chairman.

As far as one could ascertain, this represented his 27th production since being with ESTEC, most of which had provided entertainment not only for the staff but for local people also, and were very much appreciated. Those who attended the Victorian Evening were well rewarded. It was a most hilarious occasion, with ribald comment emanating from the audience at every opportunity. How the performers (all amateurs from ESA staff) managed to stay with their lines is beyond belief. Villains were duly hissed and booed, heroines in distress suitably sympathised with and heroes cheered, though nothing was actually thrown at the actors; the audience was far too good-natured for this. To round things off, a range of old Victorian songs, the words of which were thoughtfully provided, gave everyone an opportunity to let rip. Interspersed were some good old Victorian melodramas. It was an evening to warm the cockles of one's heart

The programme for the Staff celebrations also included golf, football, rugby and tennis tournaments, exhibitions of fine arts, philately and photography, an aerobatic flying display and canoeing, apart from two further repeats of the Victorian Evening.

BIS Activities

Notices everywhere heralded the fact that a technical meeting of the Society was to held on Friday morning 11 May, chaired by Tony Lawton. There were three speakers:

(a) "Space Telescope" by Jan 8urger, ESA Project Manager.

(b) "ESA's Future Satellite Telecommunications Programme" by Ed. Ashford, Head of ESA's Communications Satellites Systems Division.

(c) "Highlights of the Society's 50 Year History" by Len Carter, Executive Secretary.

It is hoped to publish the two technical contributions in a future issue of *JBIS*.

New Horizons for ESA

Sir, The European Space Agency has provided the major focus tor European space efforts for almost a decade. It has brought about some notable achievements in that time, especially considering its collaborative nature. It has dwarfed its predecessors' achievements and set a successful example for other European organisations to emulate.

Europe has developed her own independent, commercial heavy launcher. With Spacelab she has taken the first steps towards manned European space missions. There has also been the development of successful telecommunications, Earth observation and space science satellites.

Now ESA is facing a watershed period. The key programmes that were agreed in 1973 (Ariane, Spacelab, Marots/Marecs) have come to maturity and there is a need for a new set of core programmes to take the Agency into the mid- to late-1990's. This need is a powerful argument for such programmes to be at least as large-scale as those they follow. There are political issues that make it desirable there is more than one core programme.

There are three major options; they are not mutually exclusive, nor can ESA afford them all:

- Stay with current plans to exploit the commercial launcher market, adapting to lower cost/kg and cater for larger payloads, and/or develop variants for other ESA programmes. Development of the Large Cryogenic Engine (previously HM60) is a major determinant.
- Become heavily involved in the proposed US Space Station, as it seems the Japanese are ready to do. It is not yet clear what particular role would be ascribed to ESA.
- Go for a hybrid project, suggested by West Germany, called Columbus, which overlaps three project areas: Ariane, Spacelab/Eureca, US Space Station. This would involve a semi-modular system of pressurised capsule, platform, resource module and servicing vehicle. These could be free-flying or connectable to a US Space Station.

There are pros and cons, naturally. For example, there is the question of how the commercial launch market will develop. There is also the question of how closely the member states wish to become involved with the US space effort.

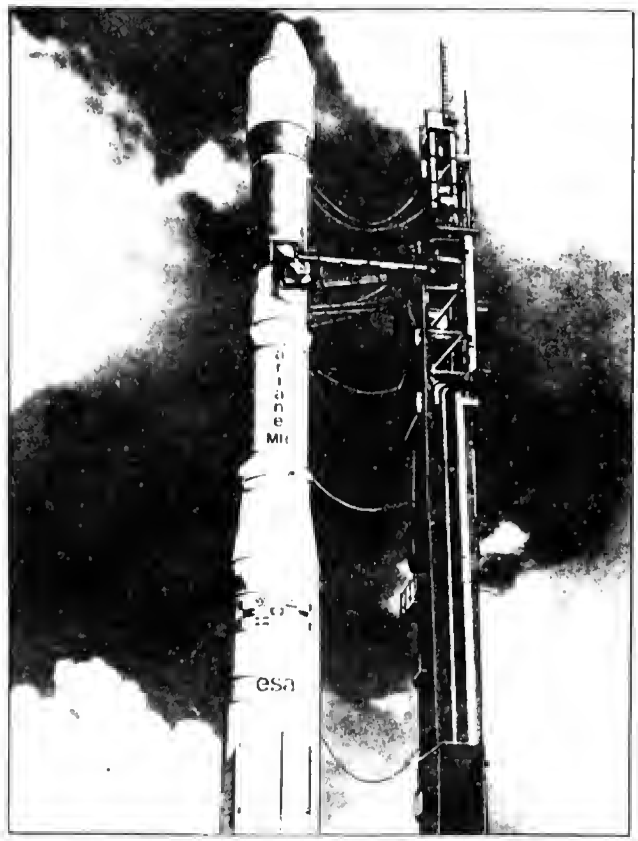
Remote sensing and direct broadcast satellites will become of major importance. Mobile satelllite communications will be of great interest. The way in which European industry can benefit from a potential 'space boom,' and how it organises itself in order to maximise such benefits, are also of importance.

N.I.J. HOPE
Oxon

Morality of Space Exploration

Sir, Ian Crawford's thoughtful letter (*Spaceflight*, June 1984, p.247) on the morality of space exploration raises some crucial points.

In a world where, increasingly, technological development is perceived by many as leading to ever-increasing expenditure on military matters, investment in space research and development can often be thought of as wasteful, yet even Third World countries are often keen to acquire the latest combat aircraft. In areas of severe poverty such equipment is meaningless to a starving peasant.



The European Ariane, now commercially operational, is a programme from the early 1970's. What direction should be taken now? *ESTEC*

It is the task of space enthusiasts, such as BIS members, to convince people - including the decision makers - that the long-term exploration of space and the utilisation of the space environment can and must be for the benefit of all mankind.

GERAINT DAY
Swindon, Wilts

The Morality of Space Exploration - II

Sir, Ian Crawford's letter on the morality of space exploration is the hoary old question raised whenever some new and costly space effort is launched. What those who ask such questions never ask themselves is how, in the light of widespread hunger and need on the Earth, they can justify their own personal expenditure on holidays, colour TVs, radios, refrigerators, "spare" clothing, etc.

It is not a question of morality so much as common sense, vision and choice. We could solve most of the problems of hunger and disease quickly if we really made the effort. At the same time we could go forward more rapidly in space exploration.

What holds us back is our self-made economic system, which is a millstone around our necks. Until we devise an escape from it, starvation and pollution on our planet will

increase and space exploration, the most forward looking of all human activities, will be hamstrung.

JOHN ALLISON
W. Midlands

The Morality of Space Exploration - III

Sir, Like most Western adminitrations, successive UK Governments have a pathological inability to consider plans beyond five years into the future, with the result that politics have become a series of petty-minded tactical manoeuvres aimed at image enhancement for the next election campaign. Although we praise 'High Technology,' we have forgotten that technology is only the study of tools, which can be rightly judged only when they are used by people who have had the appropriate training and experience to harness them fruitfully. There is little investment in the scientific and engineering research that is the seed corn of tomorrow's technology.

Furthermore, a comparison between the explosion of satellite communications over North America, which already has the best network in the World, and the almost total lack of developments over the poorer countries of the 'Third World' shows that progress serves demand and available wealth, not numbers or greatest need. Choosing between international and national agencies is, in practice, a choice between which two sets of officials will benefit most.

Mankind is not going where no man has gone before simply for the sake of the noble pursuit of knowledge to benefit all.

D.G. STEPHENSON
Surrey

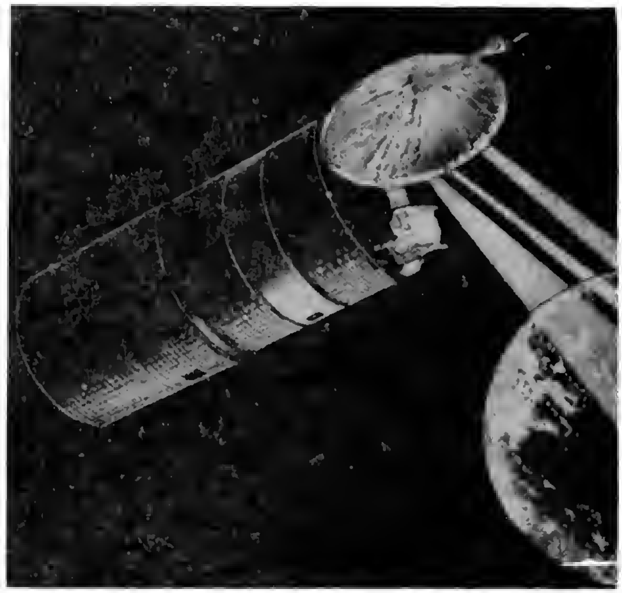
Australian Space Policy

Sir, The space scene in Australia is now more positive than before. An independent study commissioned by the government and Auspace Ltd concluded that a space industry was financially feasible, provided that initial government support was provided.

In order to poll the Science and Industrial community for the basis of a national space policy a National Space Symposium was organised by the federal Department of Science and Technology and Auspace Ltd. Some 150 representatives from Science, Industry and Government attended the two day event in Sydney on 22 and 23 March but the general level of awareness of space programme strategy was very low.

Recommendations spanned the pro-space spectrum from a conservative "we cannot be in the big league" views to aggressive joint risk sharing with major companies on new STS/Space Station based space systems. No recommendation was made about the annual funding level that could be supported. The question was not asked. The only near unanimous recommendation was for a National Space Administration to co-ordinate space policy.

The permanent secretary of the Department of Science and Technology expressed the view that a continuation of inter-departmental committees to determine space funding allocation would be adequate. The general consensus was that the NSS had achieved very little in advancing a coherent space policy for Australia, so progress will be manifest when individual companies and researchers are successful in promoting their projects as a hi-tech salvation for Australia. The much-lauded Starlab project has faltered due to the withdrawal of the Canadians who favour mainline Space Station work rather that a one-off exercise for their industry.



The Aussat satellite project provided an opportunity for an Australian astronaut. Aussat will carry two dishes. *Hughes*

Unless a more commercially attractive primary project is promoted and supported Australia will see only small work packages that foreign aerospace equipment manufacturers are obliged to offer in order to win local sales.

Australia had the opportunity to train astronauts with the Shuttle launch of Aussat. However the Minister of Science and Technology deferred the opportunity due to a lack of "Australian experiments in which an Australian Payload Specialist can participate and which will be of long term benefit to Australia." In this way he threw away manned spaceflight experience which could be of primary use in the emerging space industry infrastructure.

JOHN SVED
Stevenage

Halley's Comet

Sir, In the April issue of *Spaceflight* I came across the paragraph on p.185 concerning the comet that appeared after the death of Julius Caesar. This could not possibly have been Halley's comet, whose last two apparitions before the Christian Era were in 87 and 12 B.C.

You might also be interested in the complete version of the 1910 Halley's comet verses by H.H. Turner:

Of all the comets in the sky
  There's none like Comet Halley;
We see it with the nakey eye
  And periodically.
The first to see it was not he,
  But still we call it Halley;
The notion that it would return
  Was his originally.

Of all the years we've lately seen
  There's none to rival this year.
Because though busy we have been,
  We're likely to be busier.
When five-and-seventy years are sped,
  Then back comes Comet Halley;
He told us that it would return,
  And mathematically.

Some probe the secrets of the Sun,
  And most effectually;

There's much good honest work been done
Selenographically.
Whatever quest may prove the best,
We all admire bold Halley,
Who said his comet would return,
Perhaps perpetually.

They say the greatest man is not
A hero to his valet;
But I'd rejoice if 'twere my lot
To serve the fame of Halley.
So Cowell and Crommelin, Davidson,
Knox-Shaw, and all the tally,
We'll toast the splendid work they've done
Enthusiastically.

The first three stanzas were published in the *Observatory*, **33**, March 1910, p.150, in H.H. Turner's anonymous column, "From an Oxford Note-Book;" *Astronomer Royal* (Cambridge, 1951), Margaret D. Wilson's biography of her father, Sir Frank Watson Dyson, p.147–148.

Congratulations are in order for the special Halley's Comet issue of your January 1984 Journal.

R.S. FREITAG
Virginia, USA

Spacelab D-1 Crew

Sir, On p.253 of June's issue you report that three of the eight crew members of the German Spacelab D-1 have been named. While the commander and pilot have yet to be named, we do know that two out of Ulf Merbold, Reinhard Furrer and Ernst Messerschmid will be chosen.

After the selection of Merbold as prime crewmember for Spacelab 1, the Germans offered Wubbo Ockels of The Netherlands, Merbold's alternate for that flight, a seat on Spacelab D-1 in October 1985.

P. STUIT
The Netherlands

The Tyuratam Launch Site

Sir, Recently new information has been made public [1] about the early history of Tyuratam, the Soviet launch site. The 28 km rail extension which leads from Tyuratam to the present location of the launch complex was built before World War II. It apparently led to a quarry that later became the first pad's flame pit. It is possible that the other A–booster pads were also built on the edge of old quarries or open pit mines.

The story of how the name Tyuratam was selected by the US Central Intelligence Agency is rather unusual. Once the facility was located from U–2 aircraft photographs, it had to be named; in the 1950's new facilities were named after nearby towns. To find their place names, the CIA used World War II German maps, which were the best they had, of Central Asia and Siberia. On a 1939 map, the rail spur appeared, leading into the empty desert. At the junction between it and the main Moscow-Tashkent rail line there was the railroad station of Tyuratam (Tjura-Tam on the map. This is the origin of the hyphenated spelling one sometimes finds). Dino Brugioni, the Chief Information Officer of the CIA's photo centre, suggested this. Others argued for Novokazalinsk or Dzhusaly. Brugioni countered that they were too far away (106 km and 78 km respectively) and since the US was so open about its space programme, the Soviets would eventually give its exact location. His arguments prevailed and Tyuratam it became. After the Gagarin flight, the Soviets began referring to the site as the "Baikonur Cosmodrome" after a town 370 km away - this in spite of the fact that U–2s photographed it repeatedly.

Incidentally, although in the Kazakh language Tyuratam means "arrow burial ground," Baikonur isn't much better. It means "the master with the light brown hair."

CURTIS PEEBLES
California, USA

REFERENCES

1. *Air Force Magazine*, March 1984.
2. Personal correspondence, James Oberg, 27 March 1984.

Space Tourism

Sir, Regarding your interesting article "Tourism - Key to the Universe?" (*Spaceflight* March 1984): may I suggest that one of the things a space-tourist would like to do would be to emulate his heroes and fly a spaceship. That seems a dangerous thing to do but, simulators apart, he could command a small model spacefleet. Docking a model spaceship would be quite a challenge - and perfectly safe.

R. OLIVER
Yorks

The Docking of Apollo 9

Sir, I wonder whether anyone can solve a mystery from 1969. Pictures relating to Apollo 9 show that the Command Module and Lunar Module were docked at an angle of 90° compared with the later dockings on lunar missions. No explanation has been given for this, as far as I know.

PHILLIP CLARK
London

The two Apollo 9 spacecraft docked together in March 1969. David Scott stands in the CM hatchway while Rusty Schweichart took this picture from the LM front hatch. The two craft are clearly at 90°, while later flights had the hatches in line. *NASA*

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

MILESTONES

May 1984

4 Cosmonauts Kizim and Solovyov make their 4th EVA in 12 d to work on Salyut 7's main propulsion system, which leaked last September. They have now been aboard the station for 85 d.

4 Astronauts Byron Lichtenberg and Michael Lampton will fly in Shuttle Earth Observation Mission-1 in November 1985. Claude Nicollier has already been named.

6 Progress 20 undocks from Salyut 7; it burns up next day.

8 Progress 21 is launched at 02.47 Moscow Time to dock with Salyut 7 on 10th. It carries propellants for the station's tanks.

15 The contract is signed to provide three European Meteosat weather satellites for launch in June 1987, September 1988 and November 1990 by Ariane.

18 The Salyut 7 cosmonauts install an extra solar array during a 3 hr. EVA. Total EVA time is now 17 h 56 m.

22 Ariane V9 takes the GTE Spacenet communications satellite into an initial 200 x 36,167 km orbit. The first Ariane 3 launch, with 2 boosters, is expected in August, carrying the ECS 2 and Telecom 1A communications satellite.

23 NASA selects 17 new astronauts.

26 Exosat completes 1 year in orbit.

30 Progress 22 docks with Salyut 7.

June 1984

2 An 18 sec main engine test firing clears Shuttle *Discovery* for launch on 22nd.

6 *Giotto*, the Halley's comet probe, is transported from British Aerospace in Bristol to Toulouse in France for its final series of tests.

9 Intelsat 5 F9 is lost when its Centaur stage begins to tumble.

25 13.43 GMT launch attempt of *Discovery* called off because of onboard computer problems.

25 Plans are being finalised for a rescue of the lost Palapa and Westar satellites, in November by mission 41A.

26 Computers abort *Discovery's* launch 4 s before lift-off because of a fault in a main engine hydrogen line.

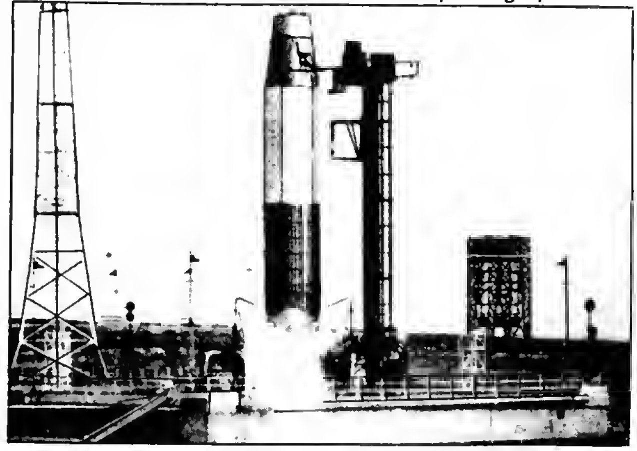
July 1984

1 ESA calls for instrument proposals for the Infrared Space Observatory, due for launch in 1992. Selection will be in June 1985.

Please note that some of the dates quoted above refer to the "announcements" of the events and not necessarily to the events themselves.

DO YOU KNOW?

Can you identify the rocket pictured undergoing a static test shown below? Answer below the photograph.



Answer: it is a Blue Streak, originally built as an Atlas-class ICBM, but then converted for use as the first stage of the Europa satellite launcher. The project was cancelled and no payload ever reached orbit. *Hawker Siddeley Dynamics*

DO YOU REMEMBER?

25 Years Ago...
14 September 1959. The Soviet Luna 2 becomes the first man-made object to reach the lunar surface.

20 Years Ago...
28 August 1964. The Nimbus 1 meteorological satellite is launched into polar orbit. Nimbus 1 provided the first high resolution TV and infrared cloud and surface photographs from a satellite.
12 October 1964. Voskhod 1 is launched with cosmonauts Komarov, Feoktistov and Yegorov aboard, the first three-man crew. They spend just over a day in space completing 16 orbits of the Earth.

15 Years Ago...
17 August 1969. NASA's Pioneer E is destroyed after 8 minutes of flight from Cape Canaveral due to a first stage hydraulics failure in the launcher.
18 September 1969. A space task force set up by President Nixon suggests that a manned Mars expedition should take place before the end of the century.

10 Years Ago...
2 September 1974. It is reported that the Soviets are modifying a static test stand at Tyuratum to accept the 122 m high Type G–1 launch vehicle in a vertical position.
21 September 1974. Mariner 10 makes its second flyby of Mercury at a distance of 50,000 km. Over 500 images are returned.

5 Years Ago...
6 September 1979. It is first reported that France has accepted an invitation from the Soviet Union to have a Frenchman launched into orbit aboard Soyuz. The mission took place in June 1982 with Jean-Loup Chretien.
20 September 1979. The third and final High Energy Astronomy Observatory (HEAO) is launched by Atlas Centaur from Cape Canaveral. The satellite provided valuable information on gamma and cosmic rays.

K.T. WILSON

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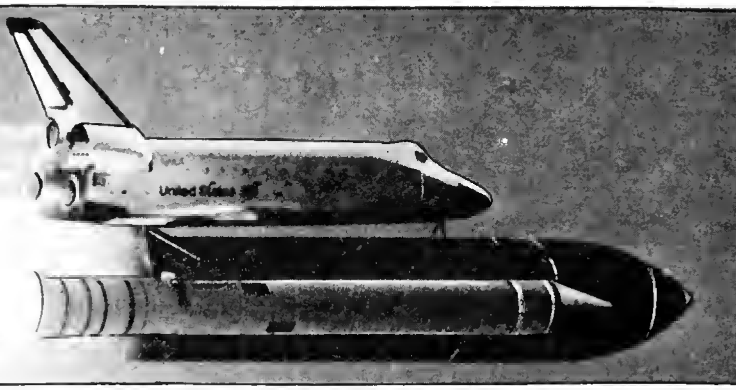
SPACE REPORT

A monthly review of space news and events



SPACE SHUTTLE

NEW ASTRONAUTS

Seventeen new Shuttle astronauts began a year's training this summer at NASA's Johnson Space Center in Houston. The 10 mission specialists and seven pilots were selected from an original 4934 applicants, 128 of whom attended final interviews and examinations at Johnson.

The 14 men and 3 women (all mission specialists) are: James Adamson (US Army), Mark Brown (USAF), Kenneth Cameron (US Marine Corps), Manley Carter (US Navy), John Casper (USAF), Frank Culbertson (USN), Sidney Gutierrez (USAF), Lloyd Hammond (USAF), Marshal Ivins, Mark Lee (USAF), George Low, Michael McCulley (USN), William Shepard (USN), Ellen Shulman, Kathryn Thornton, Charles Veach, James Weatherbee (USN).

SPACELAB REFLIGHT

As pictured on this issue's cover, BIS Fellow Claude Nicollier will fly aboard Shuttle 51H in November 1985 as part of Earth Observation Mission 1. The purpose is to refly nine of the Spacelab 1 experiments – two of them from Europe – because of the reduced data return from the late first flight of the laboratory.

With Nicollier will be scientists Owen Garriott and Byron Lichtenberg – both veterans of Spacelab 1 – and Michael Lampton and Robert Springer. Brand Vance (commander) and Michael Smith will pilot the Shuttle.

The payload specialists aboard Spacelab 3 in January will be Drs. Lodewijk van den Berg and Taylor Wang. For Spacelab 2 in April 1985 it will be Drs. Loren Acton and John-David Bartoe.

Mission 61E, in March 1986, was previously scheduled as a military mission but will now carry the first Intelsat 6 communications satellite and the Astro 1 package to observe Halley's comet. The mission specialists will be Robert Parker, David Leestma and Jeffrey Hoffman.

In late June, NASA was deciding if a rescue mission to the Palapa and Westar communications satellite, lost during 41B last February, should be included with 51A in November. Astronauts Joseph Allen and Dale Gardner have been training with devices that can be inserted into the satellites' main rocket nozzles to bring them back to the Shuttle and thence down to Earth repair and relaunch next year. Indonesia is particularly keen because it had no Palapa backup and it would take two years to build one. Commanding the mission would be Fred Hauck, with David Walker as pilot. Anna Fisher would make her first flight and Charles Walker of McDonnell Douglas would again operate the electrophoresis machine that he used on 41D.

If the rescue is not scheduled, then a crew headed by Dan Brandenstein will fly instead.

The schedule for the remainder of 1984 is:

41F, launch 29 August, Telstar 3C, SBS-D and Syncom 4-2 satellites; *Discovery.*

41G, launch 1 October, Shuttle Radar Laboratory, Earth Radiation Budget Satellite, *Challenger.*

51A, launch 2 November, Telesat-H satellite, Materials Science Laboratory, *Discovery.*

51C, launch 9 December, military mission, *Challenger.*

LATE NEWS: NASA has now decided to launch 41D in August with Leasat (Syncom), Telstar 3C and SBS. The 41F crew will be given a later flight. The effect on 41G is not yet known.

MISSION 41G

When Orbiter *Challenger* goes aloft in early October it will be carrying a crew of seven and two major payloads on a 7-day mission. The mission was originally scheduled for *Columbia* and a 30 August launch but that slot is now occupied by flight 41F and *Discovery* (see p.296 of the July/August issue for a review of that mission).

The Earth Radiation Budget Satellite will be released and much of the rest of the mission will be devoted to the Shuttle Radar Laboratory, part of which flew as OSTA on the STS-2 mission in November 1981. The aim is to acquire photographic and radar images of the Earth for making maps and interpreting geological features, as well as measuring the global distribution of carbon monoxide in the troposphere. SRL will carry the large radar antenna on three flight-proven instruments: Large Format Camera (tested on 41D in June), Measurement of Air Pollution from Satellites (MAPS) and Feature Identification and Location Experiment. FILE will classify areas according to water, vegetation, bare ground, snow and clouds.

Kathryn Sullivan and David Leestma will make an EVA, part of which will be devoted to testing techniques for refuelling the ailing Landsat 4 satellite in orbit.

Crew

Robert Crippen (commander) will be making his fourth trip aloft on the Shuttle. He flew on the first Shuttle orbital mission in April 1981 with John Young and then commanded STS-7 (June 1983) and Mission 41C (April 1984). He was originally chosen as part of the USAF Manned Orbiting Laboratory in the mid-1960's but transferred to NASA in 1969 when that project was cancelled.

has proposed that the NASA Advisory Council recommend a $25 m annual budget to provide opportunities for up to 44 such experiments a year aboard the Shuttle. Funding is for $7.5 m to be reprogrammed in the fiscal 1985 budget, $15 m in 1986, $22.5 m in 1987 and $25 m in 1988 and subsequent years.

ET TELESCOPE

An ambitious project to turn the Shuttle's external tank into an orbiting telescope has been suggested by scientists from the Harvard Smithsonian Astrophysics Observatory in Cambridge, Massachusetts, writes Clive Simpson.

They believe the 30 tonne tank, normally jettisoned after powering the Shuttle into orbit, could be adapted for use as a highly sensitive instrument for detecting gamma rays.

The huge tanks, costing $15 million and used to carry liquid oxygen and hydrogen, are at present discarded nine minutes into flight and usually fall back into the Indian Ocean. Unlike the Shuttle's solid fuel boosters, they are not retrieved. A telescope based on the external tank would be comparatively cheap to launch and the mission would still have room for a commercial payload.

Each tank is designed to operate up to 40 psi, a suitably low pressure level that would ensure the telescope walls did not significantly absorb gamma rays or become a source of secondary gamma rays due to high energy cosmic ray interactions.

Modification to an external tank before launch would be kept to a minimum with a few internal supports for telescope components and a thin outer skin of aluminium for protection against meteorites. Most of the conversion work would be done in space and Harvard scientist David Koch believes that six astronauts using manned manoeuvring units could complete the task in a single seven day mission.

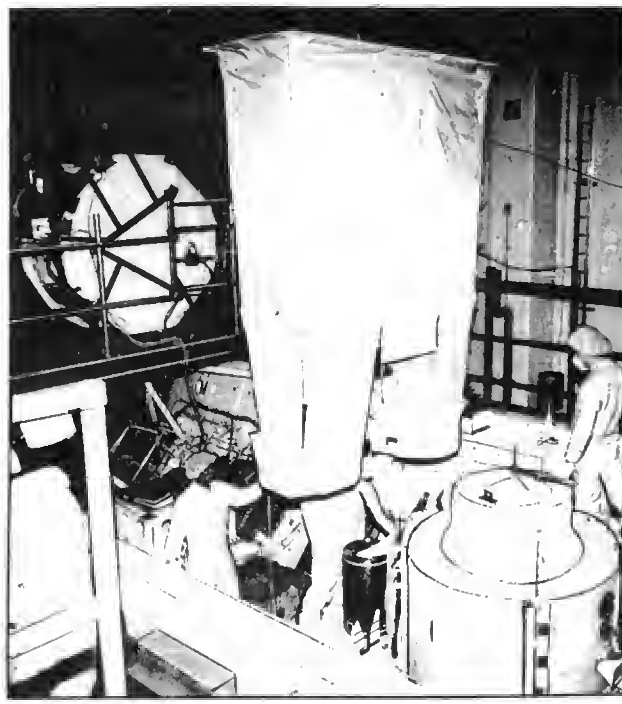
Gamma rays are thought to originate from some of the most exotic events in the Universe - exploding stars, fast spinning neutron stars and black holes - and a space-based telescope is the best means of observing them because the rays are undetectable on Earth after interaction with the atmosphere.

SPACELAB 1 FAILURE

The failure of the SEPAC (Space Experiments with Particle Accelerators) was a major disappointment in the Spacelab 1 mission last December, writes Joel Powell. It has been determined that the cause was a simple nut left behind on the Spacelab pallet at Cape Canaveral during a ground power-on test. A nut and bolt was used to secure a power cable to SEPAC during the test, which was necessary because the apparatus cannot directly be turned on in an atmosphere. The nut floated free after the Shuttle arrived in orbit, wedged between two wires in the power supply and shorted it out. SEPAC will be reflown on the Spacelab EOM-1 mission scheduled for Mission 51H in June next year.

CANADIAN GETAWAY COMPETITION

In an effort to foster interest in the space sciences, the Canadian government announced a Getaway Special (GAS) Competition last October for students and private citizens, writes Joel Powell. The winners will put small self-contained scientific experiments aboard the Shuttle in GAS canisters. Telesat Canada sponsored the secondary school portion, the segment for university students was undertaken by the National Research Council of Canada and Spar Aerospace company underwrote the competition for the general public. The winning proposals, which will go into space by 1986, include production of perfect mirrors in space (Telesat), smelting an aluminium-indium alloy (NRC) and determining whether baking yeast will rise in microgravity (Spar).



Technicians install the last major Spacelab 2 experiment, for producing X-ray images of galaxies and other extended objects, on its pallet. The mission is scheduled for April 1985. *NASA*

ASTRONOMY

TELESCOPE SENSORS TESTED

Tests of the Fine Guidance Sensors last April for the Hubble Space Telescope, due for launch in 1986, have demonstrated that the telescope will meet stringent pointing and tracking requirements, according to Jim Odom, manager of the Space Telescope Project at the Marshall Space Flight Center.

The three guidance sensors will allow the telescope to lock on to faint stars for up to 24 hours with a movement of only milliseconds of arc. This is equivalent to hitting a 1.5 cm circle at a distance of 300 km.

For the scientific observations planned for the Space Telescope, a star or object to be studied must be adjacent to two 'guide stars.' These guide stars must meet stringent criteria such as brightness, colour, position and lack of stellar companions.

"Some of the most important observations planned can be performed only near the galactic pole - regions where only very dim guide stars may be available," Odom said. "The requirement for movement of only milliseconds of tolerance in the pointing greatly exceeds that of the finest ground-based telescopes, such as the one at Mt. Palomar."

The sensors send control signals that identify tracking errors and assist in correcting them. During the tests, the two prime requirements for the sensors were to locate and lock on to a star and be able to use dim guide stars.

"Building the sensors proved to be one of the most technologically demanding tasks in the development phase of the project," Odom added.

SUBMILLIMETRE TELESCOPE

The next major astrophysical project to be initiated by NASA might be a submillimetre wave (infrared) telescope planned for the 1990's. At the recommendation of the Astronomy Survey Committee of the National Academy of Sciences, NASA plans to orbit a deployable reflector dish telescope 10 to 20 m in diameter to study light in the far infrared region of the spectrum, 50 microns to 1 mm wavelength. The Large Deployable Reflector launched from the Shuttle would provide information on stellar formation and birth in dust-obscured regions of the Galaxy and energy balance in the interstellar medium.

Salyut 6 carried the only submillimetre telescope so far flown in space; the Soviet Union and ESA both propose such telescopes by the early 1990's.

SPACE VEHICLES

RE-EMERGENCE OF OTRAG

OTRAG, the company formed in 1974 to build a private satellite launch vehicle, is now producing sounding rockets which retain the kerosene and nitric acid propellants and simplified systems of the previous OTRAG designs, writes Joel Powell. The sounding rocket, which is formed from one or two 3 m long tank segments, will eventually be capable of reaching 250 km altitude. The possibility of converting the rocket to a satellite launcher has not been ruled out by OTRAG. The first test launch on 19 September 1983 from Kiruna, Sweden (Esrange) was successful although the payload failed to operate. Peak altitude was 50 km.

NEW PRIVATE LAUNCHER

The Dolphin hybrid rocket is the latest entry into the private launch vehicle field, writes Joel Powell. The Starstruck company of Redwood City in California has produced a sounding rocket propelled by liquid oxygen and solid synthetic rubber to be launched at sea from a cradle towed behind a ship. Each sounding rocket is 15.5 m long and capable of carrying a 450 kg payload to 200 km altitude. It is planned to upgrade the rocket to a 'Constellation' satellite launcher.

The first launch attempt off San Diego, California on 6 February was scrubbed due to LOX pressurisation problems and the second attempt on 30 March was cancelled due to water seepage into an external electrical connector. A third attempt was due this summer.

SATELLITES

CANADIAN SATELLITES DEACTIVATED

In March of this year two long-lived Canadian scientific satellites were deactivated by the National Research Council (NRC) of Canada, writes Joel Powell. The polar orbiting Isis 1 and Isis 2 satellites, which performed auroral and charged particle research, operated for 15 and 13 years, respectively. They are still in good working order and Japanese scientists have asked the NRC if the pair can be revived for further research funded by Japan. The 19 year old veteran Pioneer 6 in solar orbit is the current space longevity champion.

SPACECRAFT CHARGE DISSIPATION

With a $3.5 million contract from the US Air Force, the Hughes Research Laboratories in California has developed a system to dissipate dangerous electrostatic charge buildups on orbiting spacecraft, writes Joel Powell. It is planned to use the Flight Model Discharge System on a satellite in the near future to monitor and neutralise electrical charges built up on the exterior of the vehicle. The system is an outgrowth of USAF charging research conducted with the Scatha satellite in 1979.

COMMUNICATIONS

SATELLITE DISTRESS RECEIVERS

As described in July's "Space Report," Inmarsat are looking for up to nine new satellites for its shipping communications system. Now they have asked the two bidders, consortia led by British Aerospace and Marconi Space Systems, to consider the possibility of adding distress radio beacon recovery to the craft to complement the existing Cospas/Sarsat system operated by the US and USSR. This latter service has been credited with saving up to 200 lives since it began in June 1982.

Inmarsat's geostationary satellites each view half the surface of the Earth and would thus be able to pick up distress signals immediately. Cospas/Sarsat operate in 1000 km high orbits and can take up to two hours to detect a transmission, although they provide accurate position estimates.

CHINESE COMMUNICATIONS

China has reserved two launch slots on the Ariane rocket for their TV broadcast satellites, due for flight in 1987 and 1983. Selection of the satellite builder is expected by the end of this year and places aboard the Shuttle are also expected to be booked.

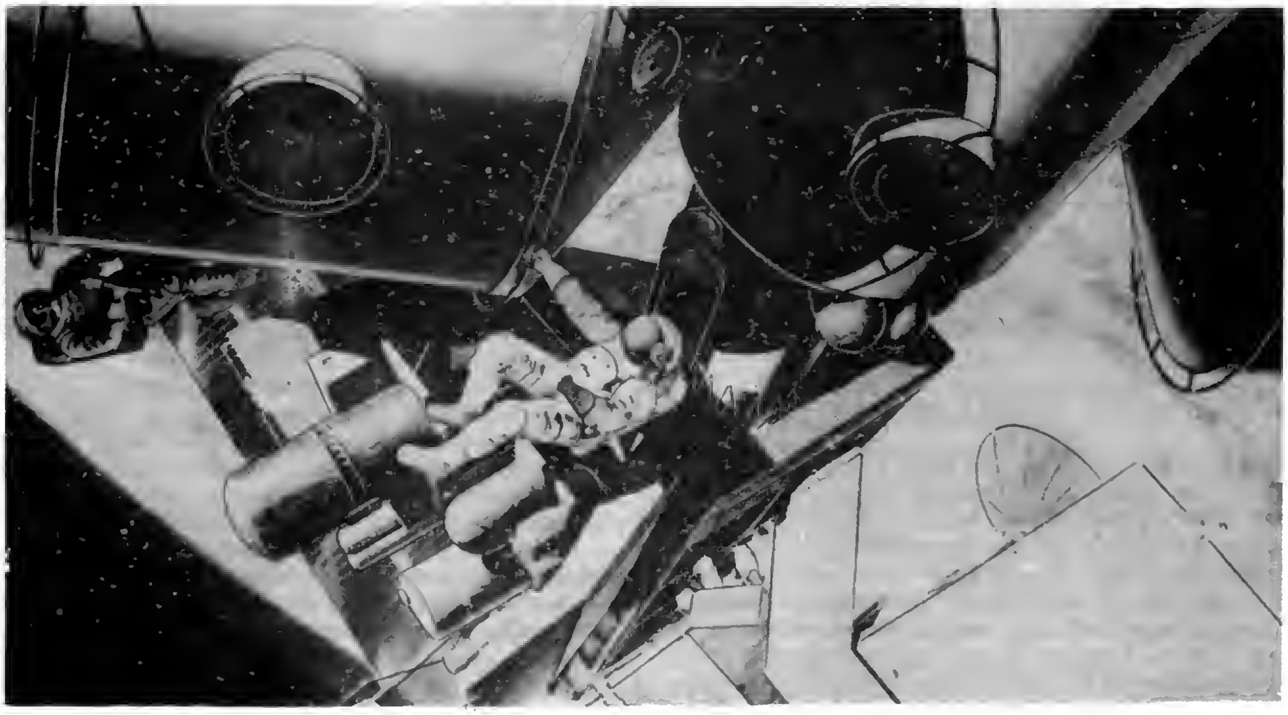
OTHER NEWS

SOVIET SPACE SICKNESS RESULTS

Results of tests made on Abrek and Bion, the two monkeys that flew for five days in December 1983 aboard the Soviet Cosmos 1514 biosatellite, have disproved a theory about the cause of space sickness, writes Joel Powell. The Soviets believed that a pressure increase in the carotid artery in the neck may have been responsible for sickness symptoms, but the flight with American-built instruments revealed pressure decreases rather than increases. The rate of blood circulation in the body also dropped during the first five days. US sickness research is concentrating on the inner ear and the stomach.

FAR-OUT VIKING

Acquiring artifacts for space museums is a competitive business these days but the US National Air & Space



An artist's impression of astronauts servicing a permanent space station. NASA/TRW

Museum seems to be ahead of the field.

The Viking 1 craft softlanded on Mars in 1976 and continued operations right up to November 1982, when it suddenly ended transmissions. Attempts by Earth-bound engineers to re-establish communications failed and the three-legged probe was left for dead.

Since it was of no use to NASA any more, so NASM reasoned, they might as well donate it to the nation's premier space collection. Ownership passed over to the museum last May in the guise of Director Walker Boyne although there are presently no plans to send out a team to bring Viking backl

SOVIET TECHNICAL FORUM

The latest Soviet Technical Forum was held at Society's Headquarters on Friday, 1 June and Saturday, 2 June 1984 with three distinct sessions. The first began with Rex Hall providing his authoritative review of the Soviet cosmonaut team. Much new information had become available since the last Forum on not only the more recent space missions but also cosmonaut groupings of the early 1960's.

The second paper was a review by Neville Kidger - well-known to *Spaceflight* readers for his Salyut Mission Reports - of the science programmes of the Salyut 6 and 7 missions. The full range of investigations covering medical, technological and pure science programmes was reviewed, with pictures of many experiments being presented to BIS members for the first time.

The final Friday paper, by Phillip Clark, reviewed the Venus probe programme from the first launch attempts in 1961 to the projected Venus-Halley missions of December 1984.

Saturday began with three films. The first reviewed the Voskhod 2 mission in 1965, which included Alexei Leonov's spacewalk. The life of Sergei Korolyov, the original Chief Designer in the Soviet space programme, was covered next, followed by a review of the first six-month mission to Salyut 6 in 1979. The Soyuz 32 cosmonauts Lyakhov and Ryumin remained on the space station for 175 days without any visitors, after a planned Bulgarian visit was aborted when the spacecraft's main engine system failed to operate.

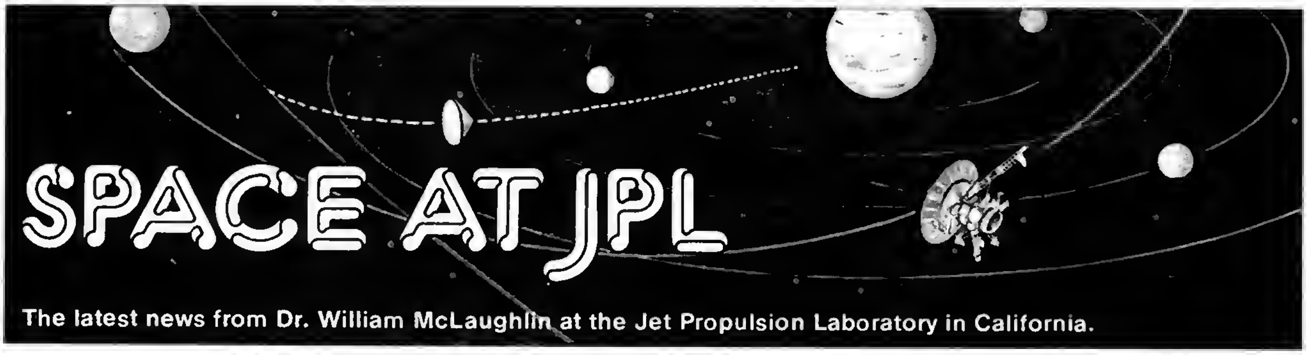
Phil Mills then discussed the making of scale model spacecraft, referring to his Salyut 6 and 7 complexes (with Soyuz-T and Progress craft) and the Cosmos 1443 module which docked with Salyut 7 in 1983. He pointed out that making the models brought two bonuses: firstly, the spacecraft could be viewed from angles that Soviet photographs do not allow and, more importantly, new design features were revealed. For example, it was noted that the Cosmos module was based upon the Salyut central section.

The final session began with Claude Watchel from France dealing with Soviet space flight design bureaus. Although many names of spacecraft and rocket system designers were known, the full details had not been brought together before. This work brought new insights into the personalities and the inter-play between the different design teams.

Phillip Clark then turned his attention to the Mars programme. Although launches began in 1960 and flights were made regularly until 1973, they had almost always ended with partial failures; the only total success was Mars 5 launched in 1973. Although no further missions have been launched for 11 years, the speaker projected the programme to include a design study for a possible Mars sample-return mission in the mid-1990's.

The meeting ended with a panel consisting of presenters Kidger, Hall and Clark opening a general discussion on many aspects of the Soviet space programme, the possibilities for the Salyut programme over the next few years being uppermost in many minds. The first launches in the new booster programme (an intermediate booster, a heavy lift booster and a heavy lift manned shuttle) were eagerly-awaited.

It is anticipated that papers resulting from the Forum will be published in future issues of the Society's magazines.



TOURING THE GALILEAN SATELLITES

The Galileo spacecraft will be launched to Jupiter in May 1986, arriving at the planet in August 1988. At 150 days before arrival a Probe will be released to enter the Jovian atmosphere and the Orbiter will continue on into orbit about Jupiter for a 20 month study of the system.

In the previous "Space at JPL" the shaping of Galileo's interplanetary flight path was examined, including the release of the Probe and a close approach to the Galilean satellite Io by the incoming Orbiter to help its capture by Jupiter. Following this gravity assist, the engine will be turned on to provide about 700 m/s propulsive manoeuvre to place Galileo into its initial orbit about the planet. Without the Io gravity assist the manoeuvre would be 150 m/s larger. Recall that the size of a manoeuvre is often measured in the metres per second change that it induces in the spacecraft's velocity: the so-called ΔV. The value quoted for this deterministic manoeuvre is quite large; on 13 November of this year Voyager 2 will perform a statistical manoeuvre of about 1 m/s in order to adjust its encounter conditions with Uranus in 1986.

The closest that the Orbiter comes to Jupiter is 3 R_J above the cloudtops (1 R_J, or Jupiter radius, is equal to about 72,000 km). The charged-particle radiation flux is rather strong at this range and thus, about 100 days later when the Orbiter has crept to its greatest distance from Jupiter, another large manoeuvre is executed to raise the closest approach on the next orbit to 11 R_J or slightly greater (subsequent orbits will remain above 8 R_J; the reduction from 11 R_J results from energy extraction from the Orbiter during close encounter with satellites).

This last manoeuvre is 350 m/s, and by this time the Galileo Orbiter will have used the bulk of its propellant and in order to conduct its tour will need to rely primarily upon gravity assists from the Galilean satellites under study; 11 targeted close encounters with satellites are featured over the span of the mission.

Jupiter rises behind a large sulphur mountain on Io in this artist's conception by Graphic Films Corp. Starting in August 1988, Galileo will explore the Jovian system. *NASA/JPL*

The Orbiter will usually approach to within 200 km of the satellite's surface during these encounters but flybys as close as 200 km or as far as 10,000 km may occur. About half of the orbits around Jupiter also have additional distant satellite encounters: from 25,000 to 50,000 km.

The celestial mechanics design techniques required to accomplish the Orbiter's tour of the Jovian system are quite complex. The original concepts for the Galileo mission were devised largely by John Beckman, Phil Roberts and Lou Friedman at JPL in the mid-1970's. Thanks go to Lou D'Amario and Roger Diehl, who have contributed significantly to the trajectory design for Galileo, for discussing their work on the tour and the interplanetary portion of the flight path discussed in the previous instalment.

SPACE RESOURCES

This month's advanced concept review considers some space resources that are to be found relatively near to the Earth. Two lines of thought suggest that space resources may assume increased importance in the not-too-distant future. First, the growing infrastructure in near-Earth space (Shuttle, Space Station, TDRSS and orbital transfer vehicles to go from low to high Earth orbit) should serve both as a potential customer for products and materials and a provider of certain services. Second, it is not unreasonable to speculate that NASA's next major goal after the Space Station could be a lunar base, for the Moon is an obvious source of materials and a location for processing.

A few factors relevant to space economics need to be borne in mind when assessing the feasibility of using extraterrestrial materials. Low Earth Orbit, which is commonly referred to as LEO and extends from about 200 to 400 km above the Earth, is more accessible from the Moon than from the Earth. It requires seven times the energy to transport 1 kg from the surface of the Earth to LEO than from the surface of the Moon to LEO using aerocapture. While this fact enhances the economic potential of lunar material for use in LEO, it is also true that material from some near-Earth asteroids can be brought to LEO with even less energy expenditure than from the Moon.

Thus, materials from the Moon or near-Earth asteroids constitute the most readily available space resources. These materials could be processed either *in situ* within autonomous or remotely-operated plants and used at their point of origin, in LEO or in geosynchronous orbit

(commonly referred to as GEO, it makes a good rhyme with LEO).

The most promising material for near-term use is lunar oxygen, which was shown by the Apollo missions to exist in abudance in rocks. Once extracted it could be conveyed to LEO for use as a propellant in transporting cargo from LEO to GEO. For example, oxygen could be loaded into the propulsion system of an orbit transfer vehicle which would then freight a communications satellite from a LEO staging position to its operating location in GEO. If hydrogen could be found on the Moon in quantity, the propellant potential of lunar materials would be further enhanced. However, future exploration is required to identify significant sources of lunar hydrogen, if they exist.

As far as we know, neither the Moon nor the near-Earth asteroids contain concentrated veins of metal such as found on Earth. This is not surprising since the geological processes are obviously quite different. Nonetheless, candidate metallurgical processes have been investigated for use in the extraction from lunar rocks of iron, silicon, aluminium and the less abundant elements of titanium and magnesium. Although much needs to be done to estimate the economic potential of these lunar metals, one could foresee obvious structural applications on the Moon for iron, aluminium and titanium, and electronic uses for silicon. In the last case (electronic) a synergistic situation might occur if lunar oxygen were successfully employed as a LEO/GEO propellant and this application were to create a market for lunar silicon photovoltaics to produce the oxygen. Numerous synergistic scenarious can be scripted with oxygen fuelling a lunar transfer vehicle, carrying a cargo to LEO and then returning to the Moon.

Perhaps the major potential of asteroids is as a source of volatile elements such as oxygen, hydrogen, carbon and nitrogen. If some near-Earth asteroids do turn out to be the nuclei of extinct comets, the prospects of finding volatiles in abundance are greatly increased.

A paper on space resources [1] has listed four priorities for exploration aimed at the discovery of space resources:

1. Examine the Moon for water ice with a Lunar Prospector Orbiter (LPrO) in lunar polar orbit. Through electrolysis, ice, which might exist in shaded craters at high lunar latitudes, could supply oxygen and hydrogen.
2. Determine whether or not Earth-Trojan asteroids exist. These hypothetical objects, named by analogy with Jupiter's Trojan asteroids, would lie at two regions along the Earth's orbit and would be very accessible from Earth by spacecraft.
3. Continue to search from Earth for accessible near-Earth asteroids and plan a rendezvous mission to them (see "Space at JPL" in the December 1983 issue for Eleanor Helin's asteroid discovery work).
4. Transient Lunar Phenomena, or 'TLP,' have been noted for years by Earth-based observers. They may represent events associated with valuable subsurface lunar gases and should be studied in more detail.

REFERENCE

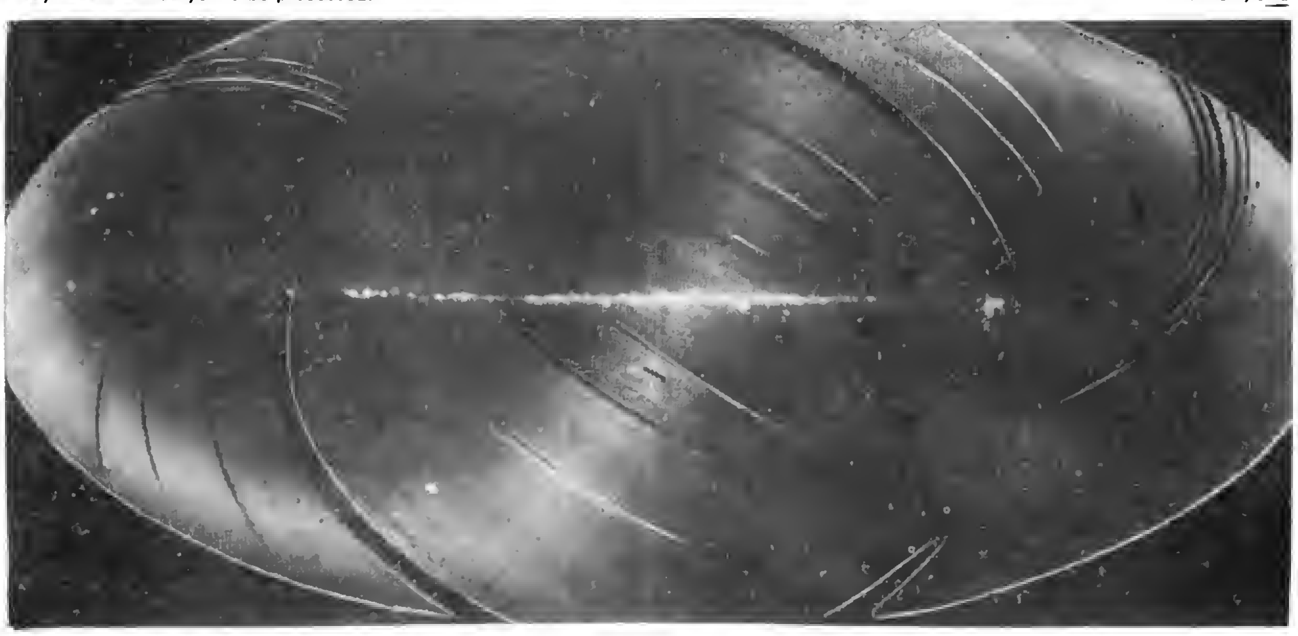
1. R.L. Staehle, *Astronautics and Aeronautics*, November 1983.

SOLAR MAX

The dramatic repair of the Solar Maximum Mission satellite in April by the crew of the Shuttle *Challenger* gave new life to the nine solar experiments onboard this NASA/Goddard spacecraft. Launched in February 1980 to investigate the Sun during the maximum portion of its 11-year cycle, the satellite returned useful data for more than nine months until it lost the ability to point accurately at the Sun due to a failure in its attitude control system in December 1980.

One of the experiments, the Active Cavity Radiometer Irradiance Monitor (ACRIM; in this case the sometimes too-prevalent acronym brings welcome relief) had returned valuable data on the Sun's energy output. The Principal

This all-sky map was constructed from observations made by the Infrared Astronomical Satellite (IRAS) during its survey of the entire celestial sphere in 1983. The bright horizontal structure lies in the plane of the galaxy, our Milky Way, and represent emission from gas and dust. The centre of the galaxy is located toward the centre of the map. Just below (South) the galactic plane and to the far right is material in the Orion region. Evidence of our Solar System is present in the broad S-shaped band which passes through the centre of the map. It arises from emission from dust lying in the plane of the ecliptic. The black regions denote lack of data: some due to areas that IRAS did not cover and some due to survey data that has yet to be processed. *NASA/JPL*



Investigator for ACRIM, Dr. Richard C. Willson of JPL, had noted variations in the solar constant caused by sunspot changes, solar granulation fluctuations and oscillations of the body of the Sun. The solar constant, which measures the energy per unit area reaching Earth, is the primary indicator of the solar output and has been the subject of study since the early 19th century.

In addition to short-period variations, Willson and his colleagues measured a 0.04% per year decline in the solar constant - if continued for an appreciable period this kind of variation could have profound implications for the Earth's climate.

Data from ACRIM should continue to be returned until at least 1988, covering the 1986-1987 solar minimum. Willson hopes that the precision of this type of measurement, already at 50 parts per million, can be improved to 1 part per million so that the data type can be extended to stars other than the Sun, yielding information concerning stellar structure and evolution.

THE EARLY LABORATORY

Clayton Koppes wrote the book *JPL and the American Space Program: A History of the Jet Propulsion Laboratory* which was reviewed in the April 1983 edition of this column. In further addressing himself to the Laboratory's history he has published a two-part essay "The Sky is the Limit: JPL and the Origins of American Rocketry" in the January and February 1984 issues of *American History Illustrated*. Oberlin College professor Koppes is vice president of the American Society for Environmental History.

His basic thesis stresses the seminal influence of the Caltech/JPL stem of American rocketry in the triad: Robert H. Goddard, Von Braun and his associates, and Caltech/JPL. Koppes traces the early work of Theodore von Kármán and his students in some detail, but the spice is added by relation of some of the lighter moments such as when the Laboratory's first director, Frank Malina, appeared at work one day wearing a necktie only to have it cut off by a mechanic on the grounds that this type of apparel was too formal!

HONOURS IN NAVIGATION & SCIENCE

A JPL navigator and a Caltech scientist long involved with the Voyager project have recently received recognition for their work: Dr. Frank Jordan received the Magellanic Premium award from the American Philosophical Society and Dr. Edward Stone was elected to the National Academy of Sciences.

The Magellanic Premium was established in 1786 by a gift from John Hyacinth de Magellan of London and is given from time to time "to the author of the best discovery or most useful invention relating to navigation, astronomy or natural philosophy." The first Magellan Premium was won by Francis Hopkinson, a jurist and signer of the Declaration of Independence, for designing a springblock device for sailing ships. Twice previously the award has settled at JPL: in 1966 it went to Dr. William Pickering, then Laboratory Director, and in 1970 to engineers Paul Muller and William Sjogren for their discovery of lunar mascons.

Jordan has worked at JPL since 1966 and until his recent appointment to the post of Deputy Manager of the Systems Division was manager of the Navigation Systems Section. He was cited for his work in the navigation of Voyagers 1 and 2 with regard to their encounters with Jupiter and Saturn. In addition, he made significant contributions to the Mariner 9 mission to Mars and has been developing advanced navigational techniques for upcoming missions.

Dr. Stone was among five members of the California Institute of Technology faculty elected to the National Academy of Sciences this year, bringing to 59 the number of Caltech faculty belonging to the Academy. The Institute operates JPL for NASA.

Election to the Academy is in recognition of "distinguished and continuing achievements in original research." The National Academy of Sciences was founded in 1863 and acts as an official adviser to the federal government. Election to this group is one of the highest honours that can be awarded to a scientist.

Stone is the Project Scientist for the Voyager mission to Jupiter, Saturn, Uranus (1986) and Neptune (1989). He arrived at Caltech in 1964 after receiving his PhD from the University of Chicago and has focused his research on planetary magnetospheres and solar and galactic cosmic rays. He is also chairman of Caltech's Division of Physics, Mathematics and Astronomy.

PRINCE ANDREW AT JPL

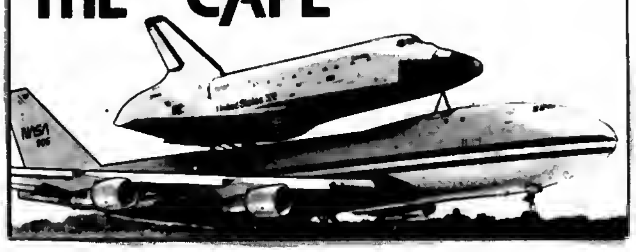
Prince Andrew visited JPL and Caltech on 19 April as part of a four-day tour of southern California. He saw a variety of Laboratory projects, including a full-scale model of the Voyager spacecraft, results from the Infrared Astronomical Satellite, the Galileo spacecraft being assembled and a working model of a Mars-rover vehicle. The prince, who is a helicopter pilot in the Royal Navy, operated the six-wheel rover.

Following the tour of JPL, he visited the Caltech campus and saw the seismological laboratory. A private lunch with a group of students and faculty members was hosted at Caltech's Athenaeum.

Prince Charles visited JPL in 1978. One of the highlights came when he sent a command to the Voyager spacecraft in flight.

On his recent visit to JPL, Prince Andrew donned a clean suit and inspected the Galileo Probe along with Project manager John Casani. *NASA/JPL*

NEWS FROM THE CAPE



The Latest Developments from Cape Canaveral in Florida

By Gordon L. Harris

US SPACE STATION

NASA Administrator James Beggs disclosed on 1 May that ESA seems willing to contribute $2000 million and Japan $1000 million towards the cost of a US-built space station. These contributions are in addition to the $8000 million that NASA will require from Congress into the 1990's when the station becomes operational, providing a home in space for six to eight astronauts and scientists.

Beggs said that he told Canada, ESA and Japan they must make "significant investment if they desire significant benefits in such matters as preferred access, crew members, payloads and so on."

Reporters covering space developments in Washington noted Congressional concern that NASA's cost projections are optimistic and that other programmes might suffer. Congressman Bill Green said that NASA should plan for both a manned and unmanned station against the possibility of too little support for the more expensive manned version. Beggs insisted that NASA will not be forced to curtail interplanetary projects in favour of the station. "Since 1980," he noted, "our budget for space science has increased £440 million, or 43%." By 1989 the science portion should reach $1,900 million, a further increase of 35%.

Beggs disclosed that Shuttle crews, "even on missions like Spacelab," come back extremely tired. He compared life aboard Shuttles to "camping out in a Volkswagon." He concluded that relying upon an unmanned station would impose too heavy a workload on crews of future Shuttles. The manned version, according to Beggs, would offer comfortable living quarters and occupants could work regular shifts without pressure.

SHUTTLE REVENUE

NASA had received almost $575 million in "user fees" for Shuttle missions up to 30 April, according to Hugh Harris, Kennedy Space Center spokesman. He cautioned that some of the total included advance payments by customers who had contracted for future missions, including "Getaway Specials," the canisters containing experiments supplied by a wide range of sponsors (newspapers, schools, universities, etc). Looking at the figures from another viewpoint, the total represents the cost to NASA of something less than three Shuttle flights since 1981.

LAUNCH DIRECTOR RETIRES

Shuttle launch director Al O'Hara has retired; his successor is Robert Sieck, who directed his first launch in February's Mission 41B.

O'Hara won an engineering degree at the University of Miami in Florida and served in the US Army Ordnance Corps. He joined the Missile Command at Redstone Arsenal in Alabama and remained there in civilian capacity as Director of Advanced Programs. He came to the Kennedy Space Center in 1963 as technical assistant to Dr. Hans Gruene, a Peenemuende veteran, who supervised the Saturn launches.

When *Columbia* made its first journey O'Hara headed KSC's site management division, responsible for modifying the Apollo facilities to accommodate the reusable Shuttles. He became director of Shuttle processing and, following STS-3, he took over from Launch Director George Page, who had to step down because of heart trouble. Fully recovered, Page is now the Center's deputy director. O'Hara supervised the successful launches of flights 5 to 9 and has now joined a Merritt Island firm marketing business computers.

Sieck earlier served as Shuttle flow manager and supervised the turnaround operations of STS-7, STS-8 and 41B. He was project engineer for the fist six Shuttle launches. He joined NASA in 1964 and served as a Gemini systems engineer, project engineer for Apollo spacecraft and engineering manager during the Shuttle Approach and Landing Tests.

IMPROVED ATLAS

The first launch of improved Atlas Centaur, capable of placing 2300 kg in geostationary orbit, came on 9 June with an Intelsat 5 aboard. Three more Intelsats and three Fleetsatcoms will be launched over the next few years. Lengthening Atlas provided 206 cm of extra tank space (130 cm to the liquid oxygen tank and 76 for the RP-1 tank), increasing the burning time by 18 seconds - earlier versions burned for 254 s.

The Atlas itself performed well but the Centaur upper stage failed during its second burn and began to tumble with the satellite still attached. The two burnedup in the atmosphere shortly later.

HIGH TECHNOLOGY

After five years and $12 million, the Shuttle toilet still doesn't work, with failures on 10 out of 11 missions. "It's been very disappointing," Dan Germany, crew systems manager at Johnson Space Center observed. On one mission Robert Gibson had to use a crowbar to free the toilet mechanism; Sally Ride and Fred Hauck employed a camera bracket. A new solution will be tested in August. Germany said "it's a bag that fits inside the commode and will be removed after every flight."

This reminded observers that NASA once spent $1 million to develop a pen to use in weightlessness. An engineer later asked "why didn't you use a lead pencil?"

ASTRONAUT DEPARTS

Astronaut Terry Hart, who rescued the Solar Max satellite during *Challenger's* April mission, is leaving NASA to resume his engineering career at the Bell Laboratories of AT&T.

THE NEW CENTAUR

By Curtis Peebles

Konstantin Tsiolkovsky realised as early as 1895 that a liquid hydrogen rocket engine would perform better than one using conventional propellents - some 40% more thrust than with a given weight of liquid oxygen/kerosene. It was not until 1958, and the start of the Centaur programme, that the problems accompanying this increased performance became apparent. The early development of the Centaur rocket stage was littered with the wreckage of test stand explosions and the failure of the first launch. The problems were solved and Centaur can now boast a better than 95% success rate. Given this record of success, the Centaur is an obvious choice for use aboard the Shuttle.

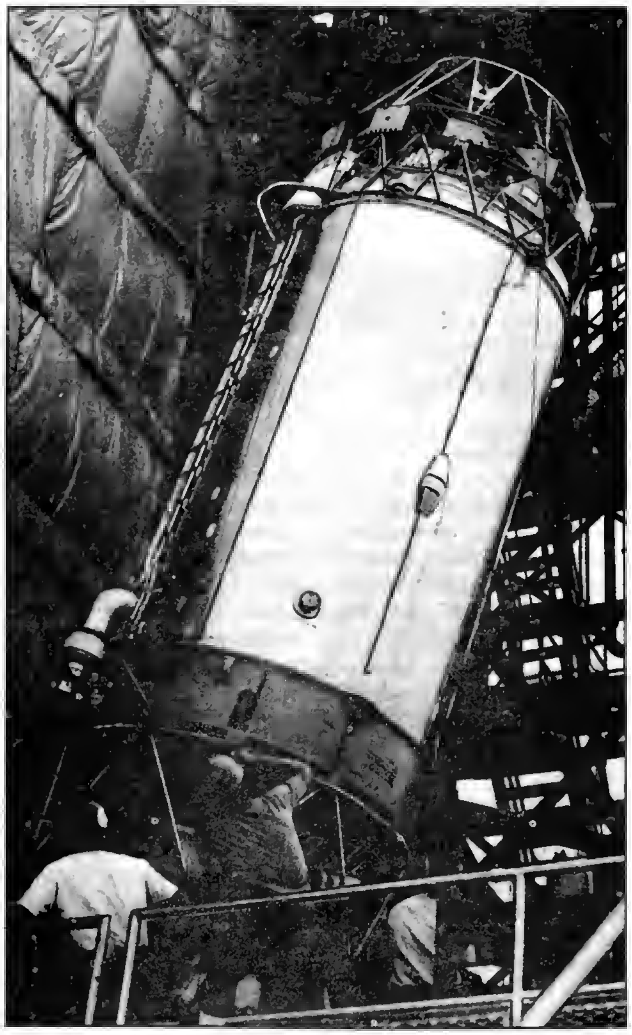
Problems with the IUS

The Boeing company's solid propellant Inertial Upper Stage (IUS) was originally chosen for use with the Shuttle, being both cheaper and easier to handle than Convair's liquid Centaur. For heavy geostationary satellites and planetary missions, a three stage IUS/Star 48 motor combination was designed - a standard two stage IUS with a small 'kick' stage. Then the ups and downs of the Galileo Jupiter project led to a switch to Centaur. When Galileo began in 1977, it was to be launched in 1982 but the Shuttle's own problems forced a delay until 1984. The less favourable planetary positions now meant that the orbiter and atmospheric probe had to be launched separately. By January 1981, the IUS/Star was in trouble - costs were increasing and it was falling behind schedule. NASA decided to switch to a modified Centaur and Galileo again became a single unit with a launch in 1985. In late 1981, however, Galileo's existence was threatened with cancellation. Ultimately, it survived but the new Centaur was not as fortunate: the US Office of Management and Budget ordered its cancellation. At this point, Congress stepped in and, after heated debate, funding for the IUS/Star 48 was dropped and money added for the modified Centaur. Two factors produced the decision: the US Air Force switched its position and supported the Centaur, and Galileo's requirements were heeded. The IUS/Star was not powerful enough to send Galileo directly to Jupiter - it would have to be sent looping out into space to re-encounter the Earth two years later. This close pass would speed up the craft and send it on to Jupiter, arriving some 2½ years later. Galileo would then be able to complete only six orbits of the giant planet rather than the 11 originally planned. The plan now is for a Centaur launch in May 1986 with arrival at Jupiter in late 1988 after following a direct route.

Centaur G and G-Prime

There will be two Centaur versions for the Shuttle: the G type for the Air Force and the G-prime for NASA. The space agency wanted higher performance while the Air Force wanted more space for their larger satellites. Both are shorter and fatter than the D-1 version used on the Atlas because of the Shuttle's payload bay. The D-1 is 3.05 m in diameter and 9.15 m long to fit the Atlas, while the new G family will make better use of the Shuttle's 4.6 m diameter and the total length of the bay.

The Centaur G is 5.95 m long and 4.33 m in diameter.



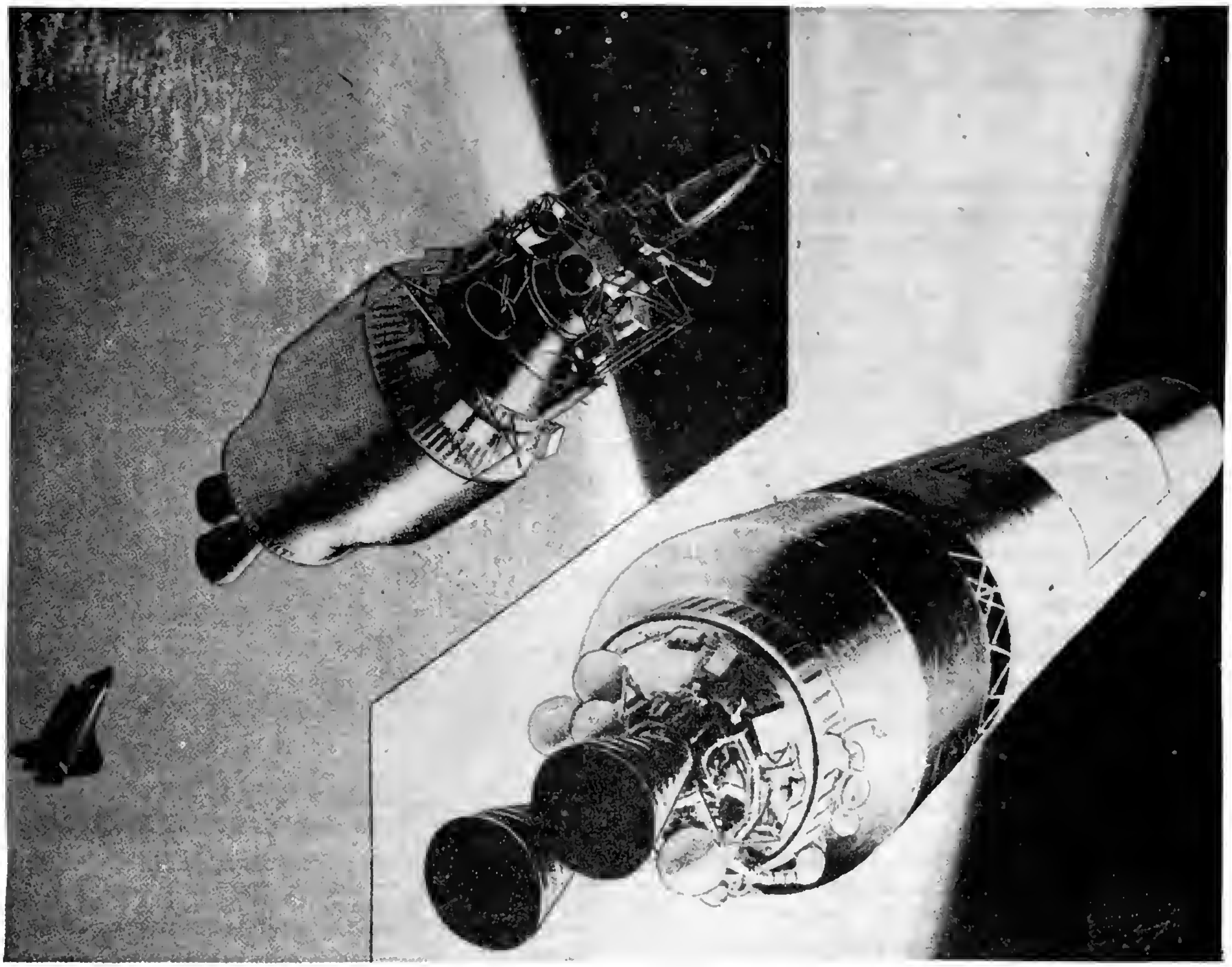
A Centaur stage is hoisted up for mating with its Atlas booster before the Surveyor 2 mission in 1966. An engine is just visible at bottom. *NASA*

The liquid oxygen tanks and the two engines are unchanged but the hydrogen tank has been shortened and widened to produce a hydrogen to oxygen ratio of 6 to 1. Satellites up to 12 m long can be handled, with 4,800 kg to geostationary orbit. In contrast, the Atlas Centaur D-1A can transfer only 1,900 kg.

NASA will use the more extensivly modified G-prime version. Its overall length of 8.9 m is only slightly shorter than the D-1's and the hydrogen tank is longer than the G's although the diameter is the same. The liquid oxygen tank has been lengthened by adding a new cylindrical section to produce a hydrogen-oxygen ratio of 5 to 1. Some 9.3 m of payload length is available inside the Shuttle and the stage can handle 6,350 kg to geostationary orbit. In both cases the engines and electronic systems remain unchanged.

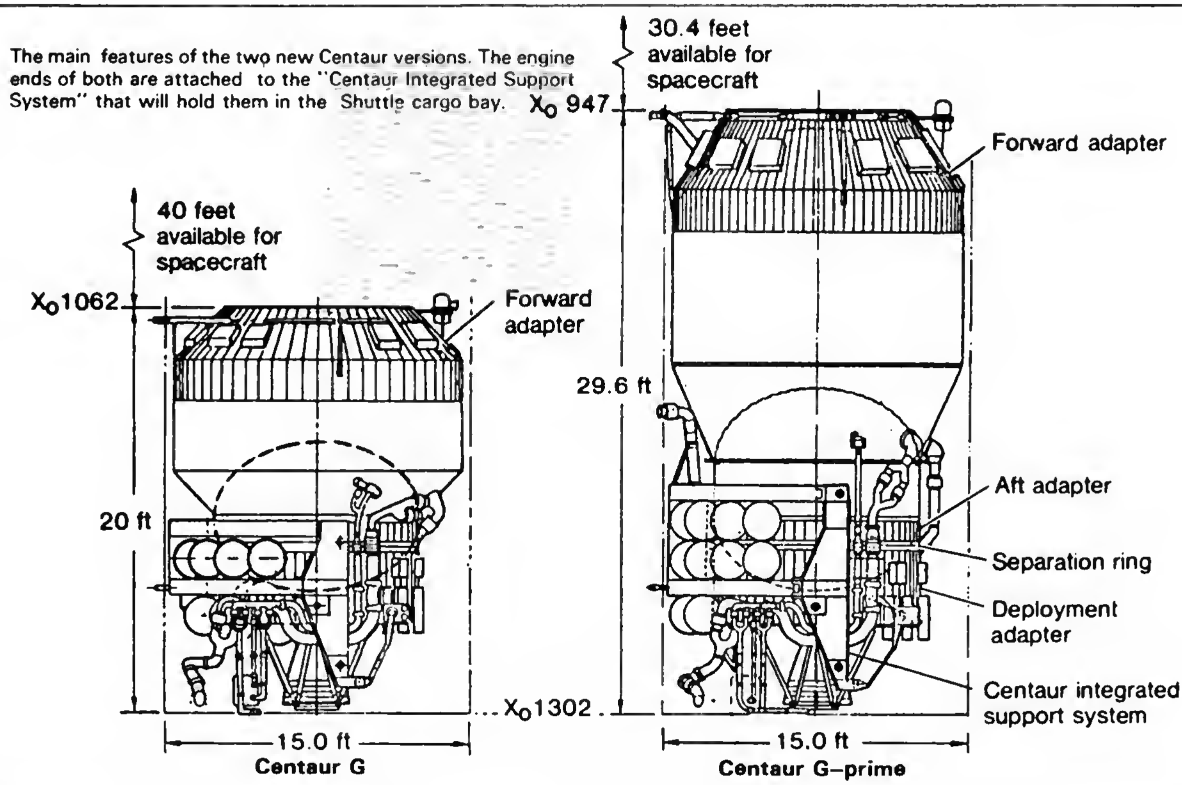
Shuttles *Challenger* and *Atlantis* will be able to carry the new upper stage. An added S band transmitter will relay Centaur's signals through the TDRS satellites and a dump system can jettison all of the Centaur's propellant through special vents in 250 seconds in case of a launch abort or a failure before the stage is released. Each Orbiter will also have an opening cut into its doors so that Centaur can be fuelled on the pad.

The stage is mounted in a ring similar to that used by the IUS. Once in orbit, the cradle is raised up by 45° and the crew fires an explosive cord to release the craft. Springs then push it out into space. If any problems appear before this the cradle can be rotated back to the



Left: Galileo and its Centaur G-prime booster. Galileo was partly responsible for the Shuttle/Centaur's approval. Dissatisfaction with the three stage IUS moved the US Congress to re-instate funding for Centaur. Galileo and the International Solar Polar Mission will be the first to use the new Centaur (May 1986). *Right:* the shorter-bodied military G version. *General Dynamics/Convair*

The main features of the two new Centaur versions. The engine ends of both are attached to the "Centaur Integrated Support System" that will hold them in the Shuttle cargo bay.



horizontal and the fuel jettisioned. Once the Centaur is free, the procedure is the same as with other upper stages - the Orbiter moves off and turns to protect its windows from the rocket exhaust.

Schedule

Shuttle Centaur development is a joint effort between NASA and USAF, directed by NASA's Lewis Research Center. The cost of developing the basic Centaur G is $270 million, with the Air Force paying up to $150 million; NASA will add another $88 million to develop the G-prime. NASA will also pay for the modifications to *Challenger* and *Atlantis* ($80 million) and the changes to the two pads (another $80 million). Convair has six of the Centaurs on order: a ground test version and two flight vehicles of each. The G-prime test vehicle should be finished this summer, with the G a year later. The two flight G-primes will be completed in the second half of 1985 for launches in May 1986 when, within a week, they will carry Galileo and the International Solar Polar Mission. Work will be finished in the second half of 1986 on the first two Centaur Gs which will carry Department of Defense satellites.

There are, as yet, no firm orders for additional stages but there have been reports that five more may be built - three for NASA for the Venus Radar Mapper and the fifth and sixth TDRS satellites, plus two for the Department of Defense (one possibly for the first Milstar communications satellite).

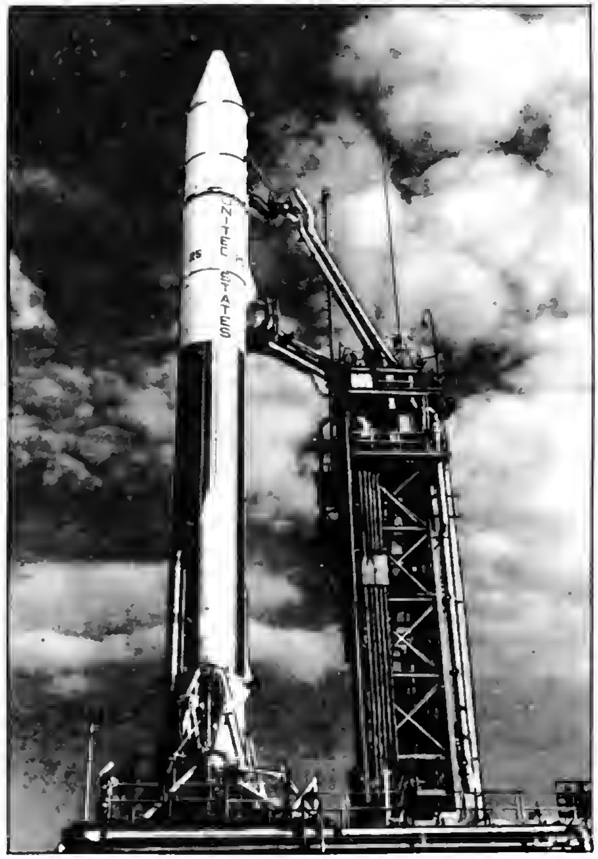
Future Developments

Using the Shuttle means that the Centaur G family will provide a flexibility unavailable on earlier missions. One factor is the size of the payload bay: the 9 to 12m length is much longer than the Atlas or Titan launch shrouds. This means that Centaur can carry two satellites on one launch, thereby cutting costs.

A future development of this is the rendezvous and assembly of payloads to produce very large structures in geostationary orbit. A dual Shuttle launch would be required: the first would carry the payload into orbit to be joined by a Centaur from the second, before ignition and transfer to a new orbit.

Another advantage is the Centaur's low thrust transfer capability, important because of the trend toward large geostationary communications platforms. The large and delicate antennae could be overstressed and damaged by a normal transfer burn whereas the new Centaur, because it can be throttled down to 20% of the total weight, avoids this problem. The first burn would raise the orbit only slightly. To reach the necessary transfer orbit a total of three perigee burns would be needed and once geostationary altitude had been reached a fourth and final burn would circularise the orbit. Using this procedure, the Centaur G could put 4,000 kg into this orbit. The RL-10 engines have accumulated 83,000 seconds of firing time at these low thrust levels. Additionally, the fifth Titan Centaur mission in 1976 tested the vehicle's ability to make multiple re-starts: after sending the Helios 2 probe on its way the upper stage made five more burns, the first after coasting in zero-g for more than five hours.

With the new family, the Shuttle acquires a heavy lift upper stage, removing a bottleneck that has always troubled the programme. With it, the Shuttle can carry larger cargoes to geostationary orbit. This, along with the ability to carry dual payloads, docking and low thrust transfers, opens up new opportunities for mission planners.



An Atlas Centaur on the pad; the upper stage carries the word "United." The '25' indicates this is AC-25 which was launched in January 1971 with an Intelsat 4 communications satellite. *NASA*

A VERSATILE VEHICLE

The Centaur high-energy upper stage reached its half century as long ago as 1978. In those 50 launches it sent all of the Surveyor soft landers to the Moon, orbited Intelsat communications satellites and sent Voyager, Viking, Helios and Mariner craft on their way into the Solar System.

The original requirements for the first LO_2/LH_2 upper stage came from plans to launch Advent, an active communications satellite, into geostationary orbit. Other objectives were capabilities to put 3,800 kg into low Earth orbit, or send 1,000 kg to the Moon or 590 kg to the nearer planets.

The Advanced Research Projects Agency awarded the contract to Convair Astronautics and Pratt & Whitney (for the engines) in November 1958, demanding a vehicle capable of long coast periods and with restartable engines. The project was handed over to NASA on 1 July 1959.

The first vehicle, launched atop an Atlas D on 8 May 1962, should have flown 1,900 km downrange from Cape Canaveral to demonstrate Centaur behaviour (ignition, guidance and separation) and Atlas Centaur integrity. The flight was going well until T+55s when the vehicle exploded at 6,000 m after the nose fairing structure failed. Tracking camera film showed the Atlas to be burning well while Centaur was breaking up.

Four failures marked the first seven Atlas Centaur flights but the Surveyor series then began a four year run of successes. The larger Titan Centaur made its debut in 1974 and scored six out of seven.

The Centaur will continue to see service with its old Atlas partner. General Dynamics/Convair will market the vehicle on a commercial basis now that NASA is using the Shuttle; two of the presently planned six Intelsat 6 communications satellites will use it, for example. *A.W.*

JBIS

The August issue of *JBIS* is devoted to "Solar System Exploration," edited by Dr. Kerry Nock of the Jet Propulsion Laboratory. The following papers are included:

1. "Planetary Observers" by W. Blume. Considers the new class of low-cost planetary mission which will use modified Earth satellites.
2. "Comet Rendezvous" by R. Draper and S. Lundy. Considers rendezvous with Comet Kopff by one of JPL's proposed Mariner Mark II spacecraft.
3. "Titan Atmospheric Probe," by B. Swenson. Shows how a new probe design can reveal the structure of Titan's atmosphere.
4. "Future Mars Exploration" by A. Albee. The exploration of Mars in the wake of Viking: particularly rovers and sample return.
5. "Starprobe: To Confront the Sun" by W. McLaughlin and J. Randolph. Examines the benefits and perils of approaching the Sun to within four solar radii.
6. "Titan Buoyant Station" by A. Friedlander. Floats in the atmosphere of Saturn's largest satellite.
7. "Comet Nucleus Sample Return" by H. Feingold. Looks at comet exploration after the flyby and rendezvous stages.
8. "Nuclear Electric Propulsion" by R. Jones and C. Sauer. Defines the advantages of continuous, low-level thrusting for propulsion of spacecraft.

This August issue is available to members at a cost of £2 ($4) post free from the Society.

1985 SUBSCRIPTION FEES

There is good news for all members: fees for 1985 will remain unchanged from 1984 in spite of rising costs.

Direct Debit Scheme

Our old Bankers Order System has been phased out. Direct Debit slips to become effective from January 1985 are now available from the Executive Secretary. They *must* be returned before 15 Nov. or else they will not come into operation until 1986 and a separate remittance for 1985 will have to be made.

Amounts payable for the calendar year January-December 1985 are as follows:

RATES

Members	Sterling	US Dollars
Under the age of 18 years	£16.00	$26.00
Between 18 and 20	£18.00	$30.00
21 years of age and over	£21.00	$36.00
Fellows	£23.00	$40.00

Age Allowance

A reduction of £4.00 ($6.00) is allowed to members of every grade over the age of 65 years on 1 January 1985.

JBIS and *Space Education*

The additional subscription payable for *JBIS*, where required as well as *Spaceflight*, is £20.00 ($34.00). For *Space Education*, it is £4.00 ($6.00).

Methods of Payment

Europe

(a) Please pay in sterling with a cheque which shows a UK address, where it can be paid.

(b) Cheques drawn in sterling payable at a bank in Europe must include £2.00 to defray charges and collection costs. Eurocheques have no charges *only* if the account number is written on the back.

(c) Banks which remit directly to the Society must be told to see that the sum is transmitted *free of deductions*.

(d) Remittances from Europe are best made by GIRO. Our GIRO account number is 53 330 4008.

USA and CANADA

(a) US dollar cheques can be drawn on a Bank which gives an address in the United States or in the UK. US dollar cheques drawn elsewhere need to be increased by $8.00 to cover collection charges.

(b) US dollar notes are accepted.

(c) US or Canadian money orders can only be accepted if *expressed in Sterling*. Internal money orders from these countries i.e. those expressed payable in dollars will be returned as they cannot be cashed in the UK.

(d) Canadian bank remittances may easily be made in sterling drawn on their UK agents. If payment is made in Canadian dollars the current exchange rate may be used, plus the addition of 8 Canadian dollars to cover exchange and collection charges.

WISH YOU WERE HERE

By David Stephenson

The age of communications is already upon us although the mass use of satellite links has not yet become commonplace. The author considers what at first sight might seem to be a trivial example but which might lead to greater developments...

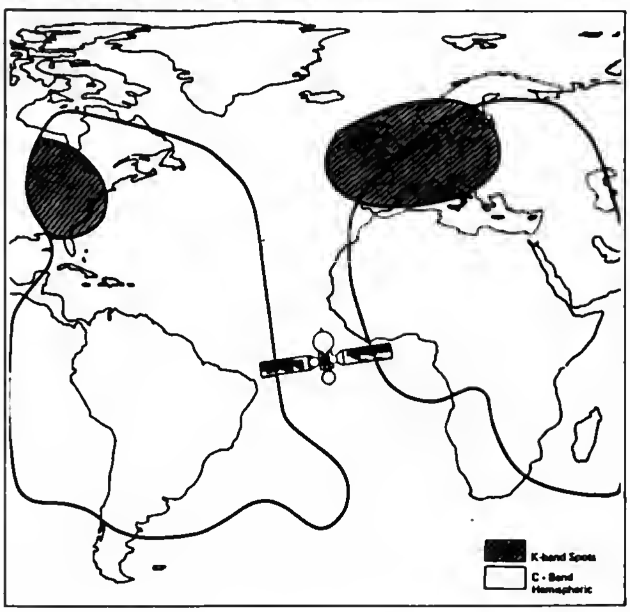
Introduction

The way that large scale integrated circuit electronics have gone from the experimental, *via* the exclusive and the expensive, to the disposable, has been the most dramatic deployment of a technology since the industrial revolution. Take the pocket calculator, for example. Space telecommunications are part of this present revolution. During the early 1960's Telstar was a thrilling but expensive experiment paid for by the giant communications and broadcasting organisations of the Western world. Today, commercial satellite links carrying pictures for TV companies are commonplace, but expensive. In the USA many larger businesses are now linked by satellite and medium sized businesses will soon be able to link into satellites at a reasonable cost. So, within a few years, we can expect space technology to handle that most humble form of long range communications, the picture postcard. Surprisingly, the exercise of estimating how much it would cost to send a postcard using present business links revealed that the 'free with 20 bottle tops!' era of space communications is already upon us.

The Global Hotel Mail Service

Third world countries would benefit most from any form of improved communications, but they certainly do not have the resources to invest in wide-spread satellite systems. However, most tourists visiting these countries usually spend at least part of their holidays in hotels that are part of international chains, which certainly do have substantial financial backing. Therefore, for this exercise, it is assumed that conventional postcards or instant prints will be transmitted as a service for guests between hotels

One option for covering the continents either side of the Atlantic. The shaded areas carry the higher-density traffic. *Intelsat*



Today's more powerful satellites allow the use of smaller Earth antennae. This version is 3 m in diameter. *Hughes*

of an international chain, using one of the many recently-announced business satellite communication services.

A postcard would have to be converted into a form that could be conveyed by satellite. A high speed facsimile transmitter could convert a postcard into digital information in a few seconds. A typical postcard measures 10 by 15 cm and the finest detail on it is 0.1 mm wide. So a three colour postcard with each colour translated into a 5 bit (32 level) density code is equivalent to:

$$5 \times 10 \times 15 \times 100 \times 100 \times 3 = 22.5 \text{ Mbits}$$

On the back the same resolution is needed but only in one colour and density, so a complete card would represent 24 Mb of data. Allowing for control and error correcting codes let us assume that one picture postcard is worth 25 Mb of data. For comparison, the small hard disc memory systems often used with small business microcomputers hold approximately 64 Mb.

An instant colour print is usually a little smaller but may have higher definition so it is also equivalent to 25 Mbits.

It has been reported that Intelsat is setting up a digital business communications service designed for medium sized telecommunications users. The transponders on their latest Intelsat 5 spacecraft will be able to communicate between modest ground stations in North and South America, the Caribbean, Africa and Europe.

The smallest ground station for this service would apparently cost $120,000 and would use one of the familiar 5 m dishes seen sprouting from the roofs of office blocks around the world. This is about the same investment that a hotel would need for an additional family suite, so is well within the budget of an international tourist hotel chain. Intelsat is offering a whole range of services from a 'thin' occasional 64 kb/sec link to a long-term leased video conferencing link at 2.048 mb/sec. If all the hotels in a chain were to be fitted to send postcards it is reasonable that they would share a common broad-

band link. Of course, this same link could be used for booking services and other internal communications.

A code will be added to the card to send it directly to the hotel or office in the chain nearest to its destination. One card could even serve several addresses, each with an individual message on the back.

The basic cost for a digital business service video conferencing link will be $10,000 per month. Since small ground stations demand more from a satellite than large stations, this basic cost has to be multiplied by 2.8 when using a 5 m dish. An additional charge of 5% for each country in an international link will be ignored since the cost of the actual transmission is only a small part of the total cost.

If a typical hotel has 200 rooms with an average of 100 families as guests, and each can be expected to send an average 20 cards each week, this gives a total of 2000 outgoing cards or 50000 Mb per week. Postcards may be second class, but they are certainly not trivial. The video links costs 0.56 cents per Mb, and so a postcard would cost about 14 cents to transmit. Each hotel would need a little under seven hours each week to transmit its quota of cards. If 16 hotels share the same satellite channel, one third of the satellite time would be left for maintenance and priority business services.

Over seven years each ground station would send 728,000 cards and if all the original cost of the equipment were to be carried by the sending of postcards this would add 16 cents to the transmission costs.

At the receiving end some form of facsimile printer would be needed to reconstruct the card. The obvious system would be a specially-developed three colour, two-sided, small format electrostatic printer. A card is about a quarter of the area of an A4 sheet that costs 10 cents to copy in one colour. A card in three colours will cost about the same to reconstruct.

Finally, the card must be delivered to its final destination. Already there is a telepost system that sends telex messages by first class mail from the nearest receiving station. In the same way, the receiving office can be expected to forward the cards it received overnight by the local first class post. This would add another 25 cents.

So sending your picture post card or instant snap will cost (cents):

Transmission cost:	14
Reception cost:	10
Equipment cost:	16
Hotel Profit and Overheads (50%):	20
Final Delivery cost:	25
Total:	85

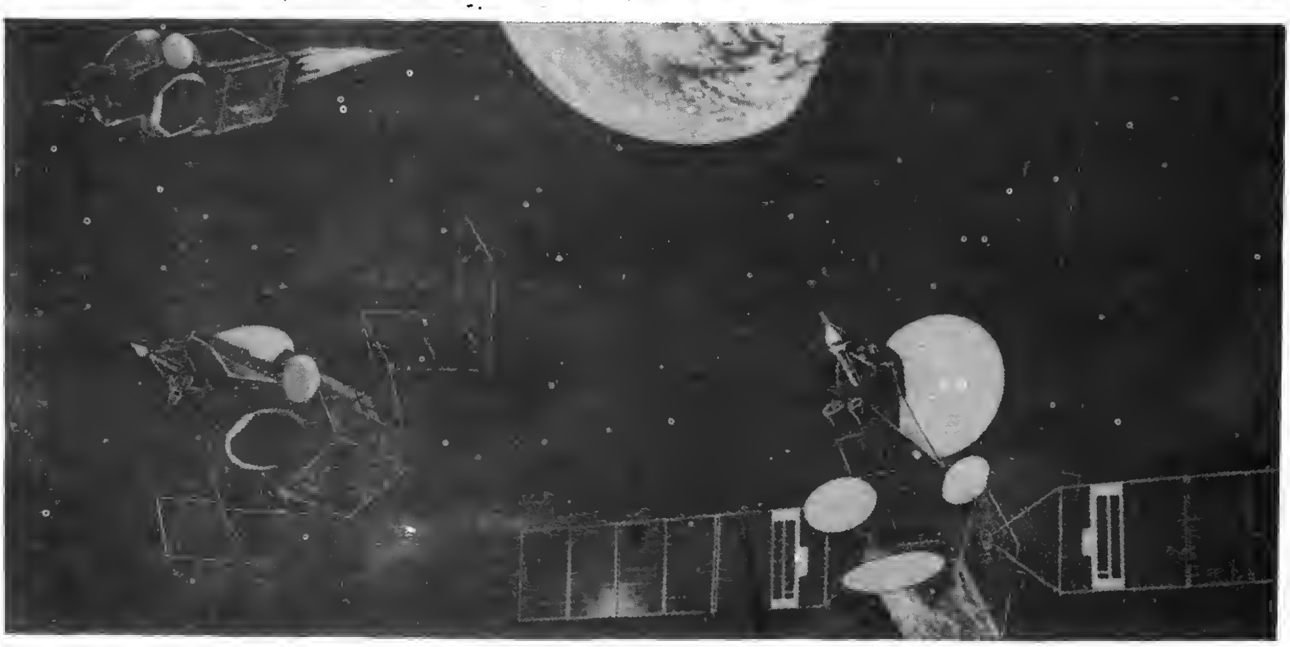
For comparison, the overseas air mail postcard rate in Britain is 38 cents. In practice, the costs will probably be even less than those calculated, for a satellite link will also be available for important premium rate business traffic.

Most resorts have an off-season and those in countries with well-developed communications sell their services to business conventions to (at least) cover their off-season running costs. The hotels in less developed countries cannot share in this trade because the convention guest cannot afford to be at the end of an unreliable telephone line for a week or more. With an overnight satellite mail drop that could include such services as stock market reports, confidential memo transfers and even digitised voice services for dictating letters to a distant office, the business guest may find the other attractions of a tropical hotel irresistable.

A consortium of Japanese camera and electronics companies are developing a portable video camera that takes still photographs on to a miniature magnetic disc that can be played back in a home video recorder. If hotel satellite links were compatible with these cameras then a tourist could send his holiday photographs for delivery the next morning to friends and family. At first this would probably mean that the hotel would have to hire out the complete camera but later, as standards developed, satellite-compatible cameras could become as common as 35 mm cameras are today.

This little exercise shows that the day of the cheap and commonplace satellite communications system is almost with us. The cost turns out to be very little more than conventional postal services. Supplying the many tourist hotels around the world with small satellite terminals could be worth many millions of dollars and it may be the only way that business-orientated satellite communications can be introduced into some of the undeveloped countries.

The Intelsat 5 series of powerful communications satellites is presently in service. *Intelsat*



THE REPAIR OF SOLAR MAX

By John Pfannerstill

The Shuttle mission of April 1984 will perhaps be recorded as one of the most significant in the early life of the spaceplane. It proved how versatile man can be working in space and demonstrated the flexibility of the Shuttle system.

Background

On 14 February 1980, a 2300 kg astronomical satellite was launched by NASA from Cape Canaveral into a 570 by 563 km orbit. After several days of tests, it was ready to begin gathering data on the Sun, then in a period of maximum activity. This task gave the satellite its rather unimaginative name: the Solar Maximum Mission or, simply, "Solar Max."

Unfortunately, on 23 November 1980, three fuses in the attitude control system blew, leaving Solar Max with no fine-pointing capability for four of its six telescopes. With no way to recover from the problem, engineers at the Solar Max control centre in the NASA Goddard Space Flight Center decided to try to salvage as much of the mission as possible. Using a weak backup attitude control system, they started it spinning at 1° per second to keep it stable and pointing roughly at the Sun. This allowed the remaining three instruments to still send back limited data. For the most part, however, the disappointed scientists had to admit that their $235 million solar observatory was out of commission.

Fortunately, Solar Max was the first of a new generation of satellites specifically designed for in-flight servicing. Thus, in early 1981, before the Shuttle had ever flown, plans were formulated for a rescue in the spring of 1984, when the satellite's orbit would have decayed to within the Shuttle's range.

On 18 February 1983, NASA announced the names of the five astronauts. Heading the crew was two-time Shuttle veteran Robert Crippen, with Francis Scobee. Like Scobee, the three Mission Specialists were also new to space: MS-1 Terry Hart, MS-2 Dr. James ("Ox") Van Hoften and MS-3 Dr. George ('Pinky') Nelson.

After a 48 hour chase, Crippen and Scobee were to stationkeep with the satellite, about 60 m away. With Van Hoften watching from the open payload bay, Nelson would don a Manned Maneuvering Unit (MMU) and fly over to Solar Max carrying a special docking device called a Trunnion Pin Attachment Device (TPAD). Using the TPAD, Nelson would attach himself at one of the 5 cm diameter trunnion pins. He would then use the MMU's jets to stop the rotation. Crippen would fly the Orbiter over to the satellite for Hart to snare it using the arm. Nelson would undock and fly the MMU back to its parking spot in the bay, while Hart moved Solar Max down to a special platform called a Flight Support Station (FSS). Locked to the FSS, the spacecraft would be able to draw power from the Orbiter while Nelson and Van Hoften performed their repair work.

If problems arose, and the satellite could not be fixed, the plan was to pyrotechnically blow the solar panels off and bring it back to Earth.

Other Payloads

The other main task of the flight was releasing the Long Duration Exposure Facility. The LDEF is a 9700 kg, 12-sided cylinder the size of a city bus, acting as a mounting platform for experiments requiring long-term exposure to space. A total of 57 experiments were mounted on trays along LDEF's outer surfaces. Some of the experiments were passive, while others had their own power supply systems and data storage. LDEF itself was totally passive, having no electronics, power supply or attitude control. It would be recovered on a later flight.

The Long Duration Exposure Facility before its release from the RMS arm. The Florida peninsula can be seen behind the "wrist" joint of the arm. *NASA*

Other payloads included a Shuttle Student Involvement Project experiment with 3300 honeybees studying how zero-g affected the honeycombs they built.

For the first time in seven missions, no Getaway Special payloads were being carried, mainly because of weight considerations. But two special camera systems would document the Solar Max capture and repair. The first was making its second Shuttle trip, having been aboard 41B in February. This was the Cinema-360 motion picture system which used special lenses and 35 mm film to create spectacularly realistic movies designed for projection onto the inside surface of planetarium domes. The second, known as IMAX (for Image Maximum), used large-format 70 mm film silimar to that used in the commercial cinema in order to produce extremely sharp and realistic showings on screens as large as 15 m tall.

Mission Day 1: April 1984

The Solid Rocket Boosters (SRBs) ignited and *Challenger*, on its fifth flight, shot off Pad 39A just 57 milliseconds after the planned time of 13:58:00 GMT (all times in GMT unless otherwise stated).

The trajectory was very different from the ten previous

flights. In order to save Orbital Maneuvering System (OMS) propellant and to reach the record 465 km high apogee required for proper Solar Max rendezvous phasing, a "direct ascent" was being flown. This meant that only one burn of the OMS engines would be required after Main Engine Cutoff to achieve the initial orbit, instead of the standard two-burn insertion of all the previous flights. Direct ascent was accomplished by burning the Shuttle main engines just a few seconds longer than usual to provide a faster cutoff velocity. This eliminated the need for the OMS–1 manoeuvre. OMS–2 was still performed at its normal time, coming about 43 minutes into the flight at 14:41. After its completion, *Challenger* was in a 466.7 by 213 km orbit inclined at 28.5 degrees to the equator. This highly elliptical path actually started the rendezvous sequence. With each orbit completed, *Challenger* closed the gap to Solar Max by several hundred kilometres.

Once safely in orbit, the crew got down to the routine business of opening up the payload bay doors, purging the fuel cells and generally getting *Challenger* set up as a comfortable home in space. This first day was a very light one. The only major activities planned were a checkout of the RMS arm by Hart, an evaluation of the FSS by Nelson and two OMS rendezvous burns by Crippen and Scobee. The relaxed day was designed to allow the crew to adapt slowly to zero–g before the hectic days to come.

Mission Day 2: 7 April 1984

The major day 2 activity was releasing the LDEF. The deployment sequence began at 14:30, when Hart used the RMS to turn a switch on the side of the huge structure to activate all the self-powered experiments. He then grappled the LDEF itself, unberthing the giant satellite and lifting it out of the payload bay.

Since the 9700 kg unit was the largest to be manoeuvred by the RMS up to that time, engineers wanted data on the arm's behaviour. Hart moved it around for an hour or so in tests very similar to those performed on STS–8 with the much lighter Payload Flight Test Article.

Hart then moved the LDEF into its deployment position. Since it has no control systems, it must be gravity-gradient stabilised with its long axis pointing to the centre of the Earth. Once in position, all of *Challenger's* thrusters were shut off and all control inputs to the RMS were stopped to allow residual arm motion to damp out. For the LDEF to maintain proper stability for ten months, no unwanted momentum could be imparted to it. After about 10 minutes, Hart commanded the RMS to release its grip shortly after 17:20 and 463 km above the Pacific Ocean.

From several hundred metres away, the crew observed LDEF for an hour to make sure it was holding steady and then moved away, leaving it to be picked up in February 1985.

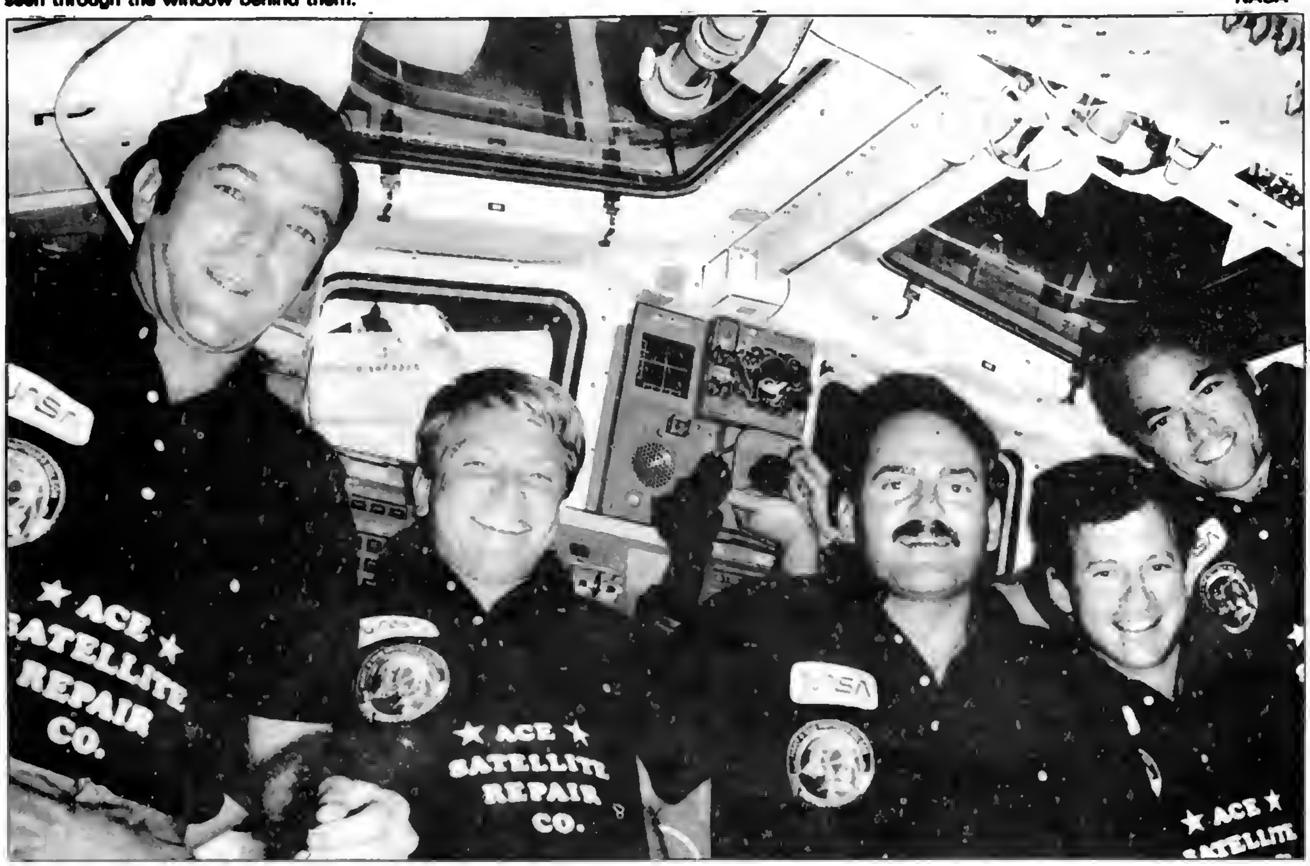
Three more OMS burns were made that day to fine-tune the approach to Solar Max.

Mission Day 3: 8 April 1984

The busiest day began shortly after 06:00 and Crippen started the work by firing *Challenger*'s engines twice. The effect was that, by 12:30, the Orbiter was just 15 km away from Solar Max. During this time, data from the Shuttle's star trackers and rendezvous radar were fed into the General Purpose Computers to calculate further closing manoeuvres. The most important of these came just 90 minutes from final rendezvous, putting *Challenger* on to a direct intercept course.

Meanwhile, Nelson and Van Hoften, assisted by Scobee, completed preparations for the EVA. Timing was critical – the two spacewalkers had to be ready to go outside as soon as the rendezvous was completed.

From left: Dick Scobee, Pinky Nelson, Ox Van Hoften, Terry Hart and Bob Crippen. The underside of one of Solar Max's solar panels can be seen through the window behind them. ***NASA***



Before long, Hart reported a visual sighting and later, from just 360 m, TV pictures sent to Earth showed a bright, formless splotch.

Crippen stopped *Challenger*'s approach at about 61 m and held that separation while Nelson and Van Hoften made final checks before leaving the airlock. The EVA officially began at 14:18 when the men started using consumables out of their backpacks. The airlock was then depressurised and shortly thereafter, at 14:30, the hatch to the bay was opened.

Shortly after egress, *Challenger*, with Solar Max 60 m overhead, moved into orbital night. While *Challenger* flew through its 45 minute "night," Nelson strapped himself into the MMU and checked it so that he would be ready as the Sun rose. Van Hoften unstowed the TPAD docking device and helped Nelson to attach it to the front of his suit. By the time Nelson had completed a 10 minute test flight inside the payload bay, it was sunrise and time for him to leave.

At 15:20, Nelson pitched over onto his back relative to the Orbiter and fired the MMU translation thrusters to move out of the bay at 0.2 m/s.

It took about eight minutes to reach Solar Max. Initially, he stayed outside of the outer edge of the solar panels while he assessed the situation. The trunnion pin he planned to dock with was between the attach points for the two solar panels. He let Solar Max slowly rotate until the pin was facing him. Then he fired his jets to move sideways at the same rate as the satellite, keeping the pin constantly in view. This allowed him to move in to dock. Unfortunately, the TPAD jaws would not clamp down on the pin. He tried three times, but he simply bounced away. This was a serious problem – if Nelson could not attach himself firmly, there was no way that he could use his thrusters to stop the rotation. He verified that the clamps were working, but that they refused to bite down on the pin for some reason.

With daylight running out, Crippen asked Nelson to try stopping the rotation by holding onto one of the solar panels. Doing that only made matters worse, however. With the unwanted momentum imparted by Nelson's tampering, Solar Max was now tumbling in all three axes. This posed a serious threat to the satellite, because there was now no way to accurately aim the solar panels at the Sun – the batteries would run down within hours.

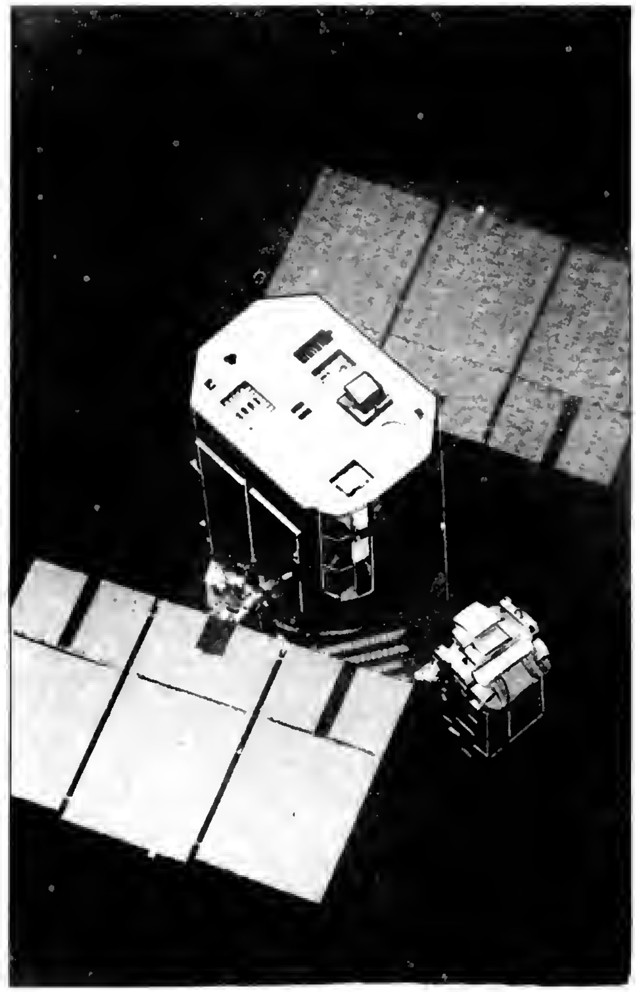
By this time, at about 15:50, there was little more that Nelson could do. He had used considerable propellant and had reached the low level mark – he had just enough to return to *Challenger*. "I can't believe it!" the disappointed astronaut said as he came back.

Crippen still had one more plan. He moved *Challenger* to within 10 m of Solar Max to allow Hart to try a hazardous "rotating grapple" even though there was a high risk of damaging both the arm and the satellite. Hart made four attempts but the rotation was just too rapid.

Crippen backed *Challenger* away from Solar Max and Nelson and Van Hoften came back inside, closing the hatch at 17:09.

The highest priority was getting Solar Max under control. It was tumbling so that its solar panels were facing the Sun for less than one minute out of every four – not enough time to charge the batteries. At normal power loads, it would be dead within seven hours, although controllers powered down all systems not absolutely necessary. At times, even the radio transmitter was turned off.

The next step was to activate the only available means of attitude control, an extremely weak set of electromagnets called "Torquer Bars." These were aligned with the three axes of rotation and were designed to interact with Earth's magnetic field to provide a light stabilising force, taking nine hours to regain control – well after battery exhaustion. No change was noted after two hours.



Nelson makes his final docking attempt on 8 April. *NASA*

Engineers suggested that the satellite's gyros were "saturated" by the high rates, giving inaccurate information to the on-board computer. As a last ditch effort, they decided to take attitude information from the magnetometers instead, although this involved sending up the proper software by radio – a process expected to take up to three hours. Time was rapidly running out.

By evening, the new computer program was loaded and the tumble was diminishing slowly. But Solar Max's power situation was not good. The solar panels appeared to be nearly edge-on to the Sun and battery voltages were dropping off rapidly. At one point, controllers notified the Houston Flight Director that Solar Max would probably not live through one more pass.

Suddenly, by sheer chance, the satellite's attitude precession carried it into a position where the solar panels squarely faced the Sun for a full ten minutes! This was enough for the controllers to use the torquers to at least orient the craft so that it was spinning about the solar axis, allowing the batteries to charge. The spacecraft was powered back up and the torquers continued their work. By 04:55 on 9 April, Solar Max was completely stopped – there was no rotation about any axis. From there on, the bars were used only to maintain a Sun-facing attitude. Solar Max was back.

Mission Day 4: 9 April 1984

The concern now shifted to *Challenger*'s propellant supply. The original Day 4 plan called for a re-rendezvous during which an attempt would be made by Hart to

grapple it with the arm. The fuel reserves were so low that only 6% was expected to be left by the time *Challenger* was stationkeeping. This would permit only one or, at best, two grapple attempts, with *Challenger* unable to manoeuvre at all. An EVA with the MMU was out of the question. If an astronaut were to become stranded by a malfunctioning backpack, the Orbiter would not have enough fuel for a rescue.

Consequently, mission control asked the Goddard controllers to break Solar Max's perfect stability and start it rotating at 0.5° per second. This would be slow enough to allow Hart to grapple the satellite easily with little chance of damaging the arm, but yet fast enough to permit several attempts with minimal Orbiter manoeuvring if the first attempt failed.

The spin-up was accomplished on Day 4, but not quickly enough to permit a re-rendezvous. Thus, the astronauts were given a rest day.

Mission Day 5: 10 April 1984

The second rendezvous began from a distance of 98 km and spanned two orbits. Propellant was extremely tight: only 20% of the forward reaction control system fuel remained but Crippen completed the rendezvous with over 10% left. This was an unexpected bonus; if Hart failed in his first attempt, Crippen would now be able to reposition *Challenger* for another try.

By 13:40, Crippen began the final approach from 60 m closing at only 0.06 m/s to save fuel and leave Solar Max's attitude undisturbed. The astronauts said nothing at all to each other or to the ground, such was the level of concentration.

As *Challenger's* orbit carried it out of radio contact mission control received telemetry indications that the arm was being moved – a sign that a grapple attempt was being made.

Excitement rose as *Challenger* approached contact with the Yarragadee, Australia ground station at 13:58. At acquisition, Crippen's voice boomed through loud and clear: "Okay, we've got it, and we're in the process of putting it into the FSS." Amid loud cheering in the control room, capcom astronaut Jerry Ross could only exclaim, "out-standing!"

Hart had been able to grab Solar Max on the first try with no problems at all. By 14:50, he had it securely berthed and the FSS electrical umbilicals were all connected to allow it to draw power from the Orbiter's fuel cells.

Mission Day 6: 11 April 1984

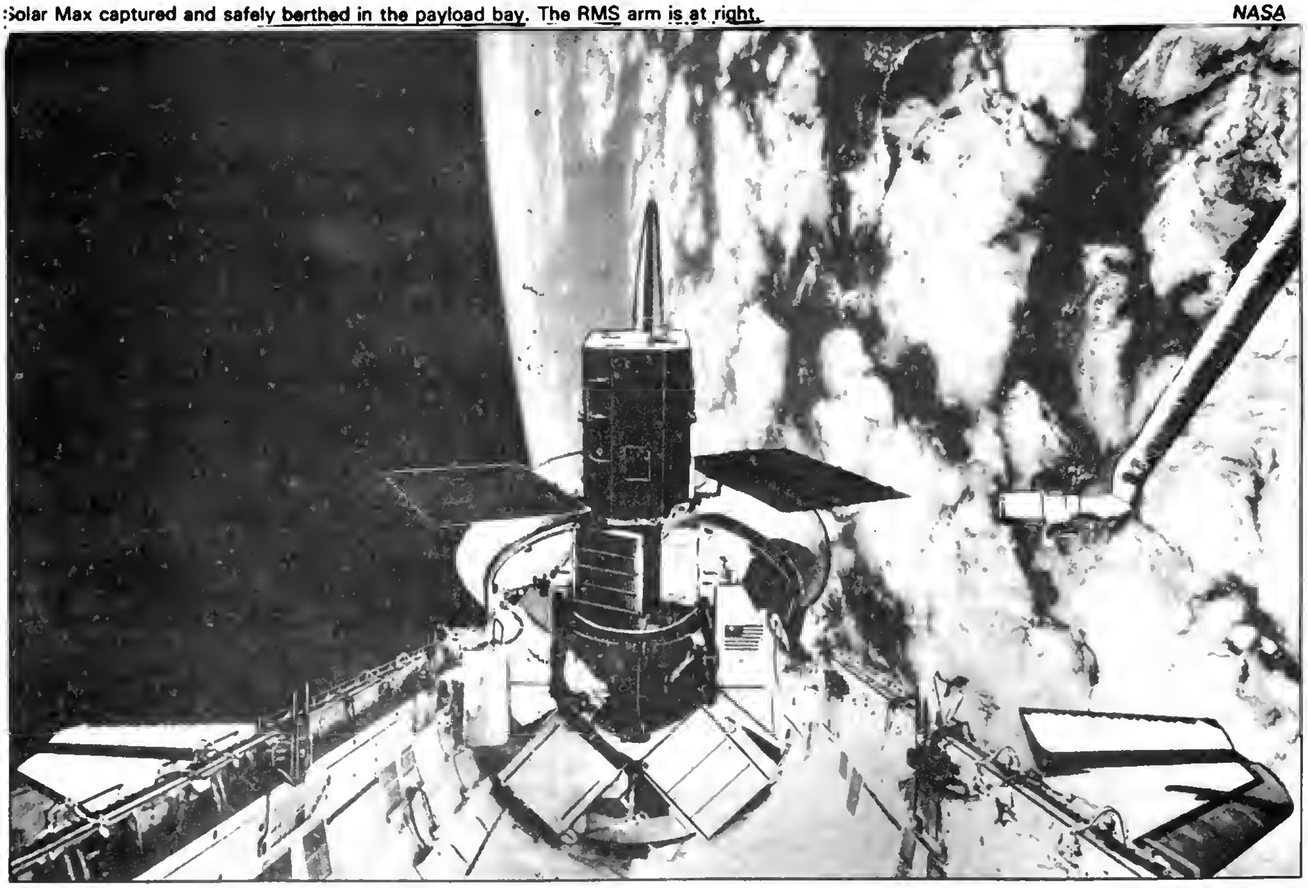
Nelson and Van Hoften moved through the airlock hatch at 09:19, an hour ahead of schedule. The first task was the replacement of the 194 kg 1.2 x 1.2 x 0.5 m Modular Attitude Control System. To make the work easier, Van Hoften stood on the Manipulator Foot Restraint, a work platform with a toolrack on the end of the arm. Hart, inside *Challenger*, could move him to any position.

The most important tool now was an electric power wrench; Van Hoften used it to loosen the two bolts holding the MACS to the side of Solar Max. The entire box was removed and replaced by a new one carried into orbit on the side of the repair structure.

The operation took about one hour and within 15 minutes Solar Max controllers reported they were receiving good telemetry data from the new unit. With the old box fastened to the FSS for return to Earth, the two repair men turned their attention to the more difficult of the two main repair tasks; replacing the coronograph Main Electronics Box.

First, however, they took a few minutes to place a small baffle over a vent port that had been allowing space plasma to enter and disrupt detectors in the X-Ray Polychromator. This simple job was expected to return

Solar Max captured and safely berthed in the payload bay. The RMS arm is at right. *NASA*



the instrument to full service.

When *Challenger* came into contact with Hawaii at 10:44, during its 76th orbit, Crippen reported that Nelson and Van Hoften were well into the MEB repair. Standing on the arm platform, Van Hoften first used a pair of surgical scissors to cut through the gold-coloured thermal insulation covering the MEB access panel. Taping the fabric back out of the way, he then used a power screwdriver to remove the fixing screws. This was hard work because, unlike the MACS, this section was never intended for in-flight maintenance. Handling the tiny screws with suit gloves was difficult but, by 11:12, Van Hoften had the panel open, exposing numerous wire bundles and the briefcase-sized MEB.

The electrical connections were held by small fasteners secured by tiny screws – 22 in all, each the size of a match head. Again it was delicate work but, by 11:45, Van Hoften reported that "the MEB is out and we're ready to put in another one."

At this point, Nelson and Van Hoften traded places, with Nelson taking over the bulk of the repair work, attaching the electrical wiring to the new unit with small screw-less plastic clips. He screwed the cover panel back and the gold insulation was taped back over Solar Max's surgical "incision." Initial data from the GSFC control centre indicated that the patient was doing well and resting comfortably. The operation was a success.

After stowing the tools away, Nelson again mounted the work platform to be lifted high over Solar Max to photograph the observatory end. The pictures would help to document the condition of the ports through which Solar Max's various telescopes peered. He also photographed the solar arrays since they had noted that sections of the glass-like material covering the solar cells had delaminated in spots.

The two men inspected the troublesome trunnion pin, finding a 6 mm long piece of insulation sticking out near it. Studies later indicated that it could have been enough to prevent the TPAD from grabbing the pin firmly. Nelson photographed it along with a small ruler to provide a scale reference.

Before going back inside, Van Hoften had a chance to fly one of the MMUs but, because of *Challenger's* dwindling fuel reserves, he had to stay inside the cargo bay.

The tired spacewalkers re-entered the airlock at 15:15, waiting 40 minutes before re-pressurizing it, however, to give Hart a chance to grapple Solar Max with the arm and lift it out of the bay. It would be left on the end of the arm overnight, allowing engineers to test it before release.

Nelson and Van Hoften set a new record for EVA by remaining outside for 7 hrs and 18 min, just 19 minutes short of the record Apollo 17 lunar surface walk.

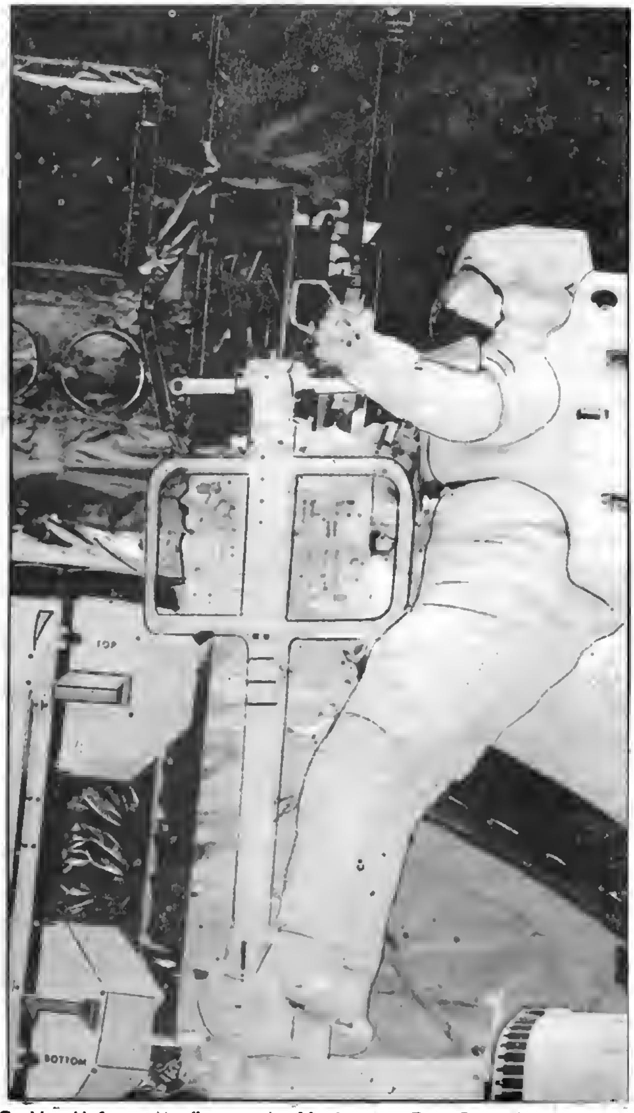
Mission Day 7: 12 April 1984

At 09:26 on day 7 the arm's jaws were released and Crippen backed *Challenger* slowly away several hundred metres while GSFC controllers checked out their 'bird.' Surprisingly, Solar Max was actually steadier than it had been right after launch in 1980!

Crippen moved *Challenger* away for the final time, leaving the beautiful blue, gold and white satellite bathed in the bright sunlight it had come to study.

Mission Day 8: 13 April 1984

Plans proceeded for the deorbit burn at 11:00 on Orbit 105, resulting in a landing at the Kennedy Space Center during the 106th pass. The bay doors were closed, the computers were configured for entry and the five crewmen



Ox Van Hoften, standing on the Manipulator Foot Restraint, hard at work changing the Coronagraph Main Electronics Box. *NASA*

donned their launch and entry helmets and strapped themselves into their seats.

At 10:36 Crippen was given a GO for deorbit in spite of the fact that a thick cloud deck was then just 16 km west of the runway. Astronaut John Young, flying in the Gulfstream Shuttle Training Aircraft, reported that the runway itself was still clear. Nine minutes later, though, it was a different picture entirely. Young reported that the clouds were heading straight at the runway.

It was now less than 15 minutes from deorbit ignition. A decision had to be made quickly, for, once the burn was completed, *Challenger* would be committed to landing at Kennedy – no matter what the weather was like. At 10:51, capcom Guy Gardner told Crippen of the "wave-off" for one orbit in the hope that a landing could be tried on the following pass. California was chosen when forecasters decided that Kennedy's weather would not improve.

The deorbit burn was performed at 12:29, the 248 second firing subtracting 505.8 k/hr from the Orbiter's velocity. In addition to the four standard roll reversals to bleed off speed and fine-tune the trajectory, the spaceplane made nine test manoeuvres to gather additional aerodynamic data.

The main landing gear wheels touched the dust of lakebed runway 17 at precisely 13:38:05, giving a flight time of 6 d 23 h 40 m 5 s.

LIFE SCIENCES SPACELAB

By John Bird

In contrast to Spacelab 1, future Spacelab missions will usually be dedicated to one discipline. An example is the Space Life Sciences Laboratory, originally known as Spacelab 4 and due for flight in December 1985.

Introduction

The objective of the first SLSL is to study the effects of weightlessness on plants and animals, with emphasis on the physiological adaptation of the human crew.

Flight operations will be similar to Spacelab 1 in that it will be launched from the Kennedy Space Center into a 300 km orbit and a long Spacelab module will be used. However, Orbiter *Atlantis* will fly for only seven days and at an inclination of 18.5° (instead of 57°).

The Experiments

Twenty four experiments are planned, totalling 1400 kg out of a payload weight of 8000 kg and covering: cardiovascular, vestibular, renal/endocrine, haematologic and immunological systems. Other areas involve muscles, demineralisation of bones and gravitational biology.

Six involve cardiovascular adaptation. For example 'Cardiovascular Adaptation to Zero Gravity' compares cardiovascular activity while resting and exercising. The 'Influence of Weightlessness upon Human Autonomic Cardiovascular Control' experiment involves application of a range of pressures to the subject's neck.

Rats are used as subjects in two experiments: 'Correlation of Macro- and Micro-circulatory Alterations During Weightlessness' and 'Cardiovascular Adaptation of White Rats to Decreased Gravity of Space Shuttle/Spaceflight Conditions.' Finally, 'Pulmonary Function During Weightlessness' involves study of gas exchange in humans.

Space Sickness

Many astronauts have had problems adjusting to weightlessness during the first few days of space flight. This is called the Space Adaptation Syndrome (SAS) by NASA and it has received a great deal of attention because of its effects on crew performance. SAS is associated with the balancing apparatus of the inner ear, the so-called vestibular system. To understand the cause and, hopefully, develop a cure, the Vestibular Experiments will study the relation between the visual system and the vestibular system. Some of this will be a continuation from Spacelab 1.

Metabolism of salt and water as well as fluid shift are the focus of interest in the renal/endocrine experiments. 'Fluid-Electrolyte Regulation During Spaceflight' will involve sampling crew urine and blood; samples will also be taken from monkeys in 'Fluid and Electrolyte Homeostasis During Spaceflight: Elucidation of Mechanisms in a Primate.

In another area, haematology experiments will examine the loss of blood cells. 'Regulation of Erythropoiesis During Spaceflight' will draw blood samples from rats. Others are 'Regulation of Blood Volume During Spaceflight' and 'Influence of Spaceflight on Erythropoiesis in Man.'

In space, muscles are not used much and they tend to atrophy. Three experiments will study rats for these effects: 'Effect of Zero Gravity on Biochemical and Metabolic Properties of Skeletal Muscle,' 'Skeletal Myusin Isoenzymes in Rats Exposed to Zero Gravity,' and 'Electron Microscopy, Electromyography, and Protease Activity of Rat Hind-Limb Muscles.' Human muscle protein will be studied in 'Protein Metabolism During Spaceflight.'


Owen Garriott (left) takes samples from Byron Lichtenberg during the 10-day Spacelab 1 mission in December 1983. *NASA*

A major problem for astronauts is the loss of minerals from bones. This effect was studied in Skylab and was found to continue as long as the crew was in space - particularly significant for long flights. Two experiments will study this phenomena: 'Pathophysiology of Mineral Loss During Spaceflight' and 'Bone, Calcium and Spaceflight.'

Four experiments will study: 'Thermoregulation in Primates in the Space Environment,' 'Gravitropic Response of Plants in the Absence of a Complicating G-Force,' 'Post-Illumination Onset of Nutation at Zero Gravity' and 'The Effects of Weightlessness on the Development of Amphibian Eggs Fertilized in Space.'

SALYUT MISSION REPORT

By Neville Kidger

Continued from the May issue

The occupation of the Salyut 7 space station continues, with cosmonauts Kizim, Solovyov and Atkov welcoming aboard the first Indian spaceman.

Soyuz T–10 in Space

The Soviet Union was preparing for 1984 to be a busy year in space as the results of the Soyuz T-9 expedition were analysed. The first indications of a new long-stay mission to Salyut 7 came in January when the Soviets announced that the planned joint flight with India would take place in early spring.

They pointed out that the successful EVAs by Lyakhov and Aleksandrov (see the previous Mission Report in May's *Spaceflight*) ensured that more power was available for scientific experiments. The "traditional" role of Earth observation and photography would be a major part of the forthcoming long-stay mission.

The crew of Soyuz T–10 (the 26 September Soyuz launch abort did not receive a designation) consisted of: Flight Commander Leonid Kizim, joined the cosmonauts' detachment in 1965 and flew in Soyuz T–3 to Salyut 6; Flight Engineer Vladimir Solovyov, an engineer, became a cosmonaut in 1978; Cosmonaut Researcher Dr. Oleg Atkov (born 9 May 1949) began space flight training in 1977. Kizim and Solovyov were reserve crewmen for Soyuz T–6 (with French cosmonaut Patrick Baudry) and the 26 September launch abort crew.

Atkov had joined Kizim and Solovyov in September 1983 to prepare for Soyuz T–10 as the first representative of a group of scientific researchers whose existance was rumoured in 1978. He graduated from Moscow's Sechenov Medical Institute in 1973 and helped to develop the portable ultrasound cardiograph used by the Elbrusy crew during their 211–day flight in 1982.

The new crew's call-sign was *Mayak*.

Soyuz T–10 was launched at 1207 (all times GMT) on 8 February 1984 and docked with the front unit of Salyut 7 at 1443 the next day. The cosmonauts entered Salyut some three hours later and found a letter and flowers from the previous crew.

SALYUT CHRONOLOGY

8 Feb 1984: Soyuz T–10 launched with Kizim, Solovyov and Atkov.

9 Feb: T–10 docks with Salyut; crew enters.

21 Feb: Progress 19 cargo craft launched, docks with Salyut's rear unit on 23rd.

25/26 Feb: Orbit raised to 305 x 307 km.

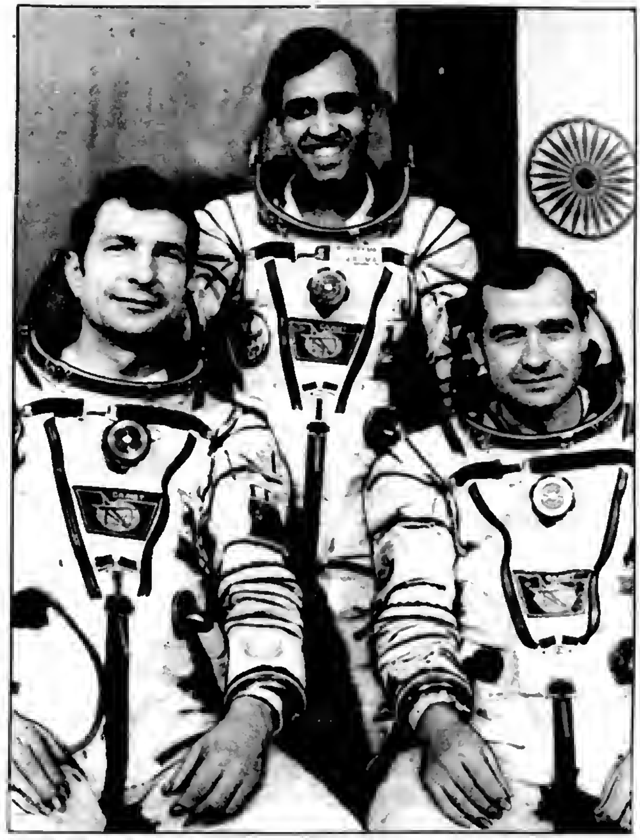
31 Mar: Progress 19 undocks and reenters destructively on 1 April.

3 Apr: Soyuz T–11 launched with Malyshev, Strekalov and Sharma. They dock with Salyut on 4th.

11 Apr: Malyshev, Strekalov and Sharma leave in Soyuz T–10 and touchdown at 1050 GMT.

13 Apr: Soyuz T–11 is moved from rear to front of Salyut in preparation for new Progress cargo ferry.

15 Apr: Progress 20 is launched; it docks on 17th.



The Soyuz T-11 crew. From left: Malyshev, Sharma and Strekalov. *Novosti*

They first had to convert Salyut's systems from automatic to manned mode, reactivating the life-support, power control and heat control systems. The temperature was stabilised at 20°C (68°F) and the pressure was measured at 756 mm on the mercury column on 10 February. Kizim was quick to test out the manoeuvrability of the station using the manual controls and Atkov was equally eager to begin in-depth studies of the cosmonauts' adaptation to weightlessness using the battery of Salyut medical monitoring equipment. Photography of the station's portholes was conducted on 13 February in readiness for the Earth observation work.

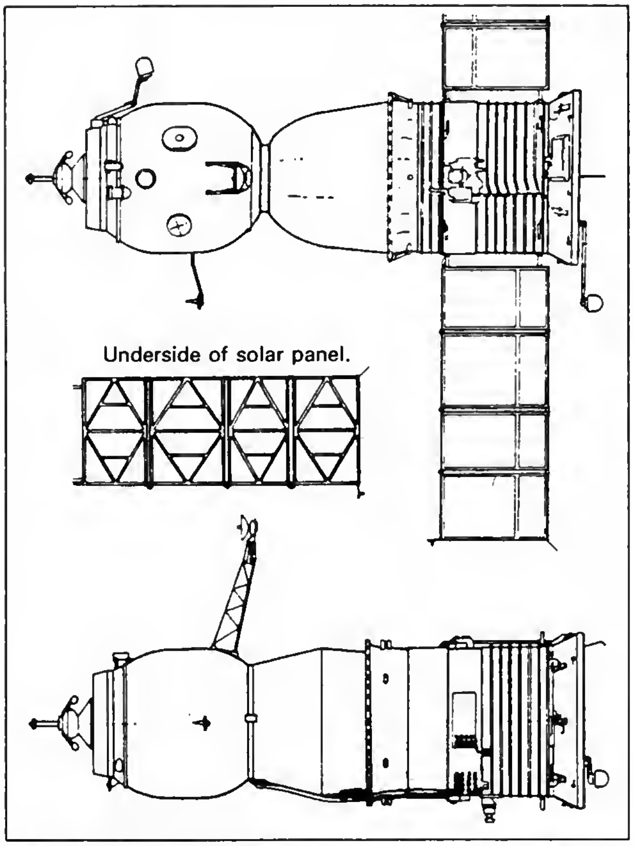
Atkov found it was necessary to replace some parts in the Aelita–01 medical monitoring device. By 14 February the crew reported that 80% of the station had been 'de-mothballed' and that loading of the Earth resources cameras with film had begun. Several minor repairs to the plumbing, hot water supply system and other systems had been made. In his first medical report from orbit, Atkov noted that although the cosmonauts had felt a slight flow of blood towards their heads during their first hours in orbit they had had no trouble in starting work on the first day. Soviet spokesmen stressed that Atkov's main studies were related to the cardiovascular system and the process of salt and water exchange in the human body - data vital for prolonged space flights.

On 15 February the station's orbit was raised slightly.

Orbital Routine

The Mayaks were scheduled to work for six hours per day as against the 4.5 hours of earlier crews. However, owing to their reportedly high fitness, partly due to a new system of physical exercises, FCC (mission control) was considering raising the working day to 8.5 hours.

The first photography of the USSR, using the fixed cameras was conducted over the Soviet Far East and the Maritime Kray on 16 February.



The Soyuz T (top) and Progress craft. *M. Mackowski.*

Progress 19 Joins Salyut

At 0646 on 21 February Progress 19, an unmanned cargo spacecraft, was launched from Baikonur. At 0821 on 23 February it docked with Salyut's rear unit, bringing over two tonnes of propellants, scientific equipment for the Indian flight and other experiments, consumables and mail for the Mayaks.

On previous flights the cosmonauts had unloaded the cargo spacecraft in three or four days; this time that was extended to allow the Mayaks to continue their scientific research. The first photography of India was conducted under the joint "Terra" experiment.

Using the French "Piramig" camera, the cosmonauts took ultraviolet pictures of Comet Crommelin, which was close to Earth in late February, as part of the VEGA project in which Soviet Venera-type probes will study Comet Halley in early 1986.

Progress also delivered a new ultrasound cardiograph instrument to provide hard copy readouts in addition to the TV pictures from the earlier version, the French Ecograph instrument. Another new instrument, the Torosion unit, was designed to study the strengths of various materials when exposed to open space. The unit was installed in Salyut's docking module.

Atkov activated the Yelena gamma detector in late February and joined his companions on the many scheduled Earth observations and photography sessions. The work kept the crew so busy that they had to leave their regime of physical exercises on the KFT trainer for two consecutive days in early March. The frequent comprehensive medical checkups by Atkov prompted Solovyov to report, on one occasion, that he and Kizim were queueing again at the door of Atkov's surgery. A new instrument, the Glucometer, was used by Atkov to determine the cosmonauts' carbohydrate metabolism.

On 25 and 26 February the men changed the orbit to one of 305 x 327 km and 90.6 minutes. By 12 March all the supplies of water and oxidizer delivered by Progress 19 had been transferred.

On 28 March, in preparation for the Indian mission, the Mayaks conducted a thorough checkout of the Soyuz T–10 systems (which was to be used by the Soviet/Indian crew for their return). For the first time, the Mayaks used the Earth-orbit TV link to receive two-way TV of the checks and instructions from FCC. On 30 March Progress 19's propulsion unit fired to adjust the orbit in readiness for the launch of the international crew.

At 0940 on 31 March Progress separated from Salyut and flew to a destructive reentry over the Pacific on 1 April.

India's First Cosmonauts

The idea of a joint Indo-Soviet space flight was first suggested during the visit in 1961 to India by Yuri Gagarin. In 1978 the idea was again raised with Prime Minister Desai and finally, in 1980, agreement was reached between Mrs Gandhi and Mr. Brezhnev. It took the Indians about a year to whittle down some 150 applicants for the flight to just eight. Further tests reduced this to six, who were then sent to the USSR for evaluation.

On 20 September 1982, before leaving for a visit to the USSR, Mrs Gandhi told the Indian parliament that two pilots had been sent to Moscow that month to train for the flight. The two were Wg Cdr Ravish Malhotra (b. 25 December 1943) and Sqd Ldr Rakesh Sharma (b. 13 January 1949). When Mrs Gandhi visited the Brezhnev Star Town on 23 September 1982 she was able to meet the two pilots who were then setting up home on the 13th floor of one of the town's flats.

The pilots were described by Boris Volynov as "goal-oriented people with lots of energy." Sharma was born in Hyderabad, where his parents still lived, while Malhotra was born in Calcutta. Sharma had 1,600 hours flying time to his credit and Malhotra 3,400 hours.

Training for the Mission

Working days at Star Town lasted from 0900 to 1815 (Moscow Time) and after work the Indians could indulge in sports. In winter (they spent two in the Town) they learned to ski.

One of their first tasks was to master the Russian language. By the end of their initial six-month theoretical training course they were speaking the language and taking their lecture notes in Russian. They began to familiarise themselves on the Soyuz T simulator at the end of April 1983.

On 24 June 1983 they were taken to the Black Sea port of Fedosia for splashdown training. During these

Rakesh Sharma (right) and backup Ravish Malhorta.

exercises photographs were released showing Malhotra accompanied by cosmonauts Yuri Malyshev and Nikolai Rukavishnikov; Sharma was in the company of Anatoli Berezovoi and Georgi Grechko. It was assumed that these were the crews which would make the actual flight to Salyut 7, with the Malhotra crew as the prime choice.

On 3 July the cosmonauts arrived back in India for a month's holiday. They were to return in August to be paired off with their respective commanders and flight engineers. During their holiday, Sharma and Malhotra were sent to the various Indian centres preparing equipment and experiments for the flight for familiarisation training.

On 6 October 1983 the crews for the joint flight were officially named. The prime crew consisted of Malyshev, Rukavishnikov and Sharma; the reserve crew was Berezovoi, Grechko and Malhotra. The selection of Sharma as prime crewman was said by the Indian press to be a result of his better command of the Russian language (he also speaks Punjabi, Hindi, Telagu and English).

However, in late February 1984, the Soviets announced that Rukavishnikov (who would have been making his fourth space flight and his third attempt to board a Salyut station - the other two attempts ended in failure) was taken ill and replaced on the prime crew by Gennadi Strekalov. Strekalov had been involved in the Soyuz launch abort only five months before and, during the training for Soyuz 22, had worked with Malyshev on the backup crew.

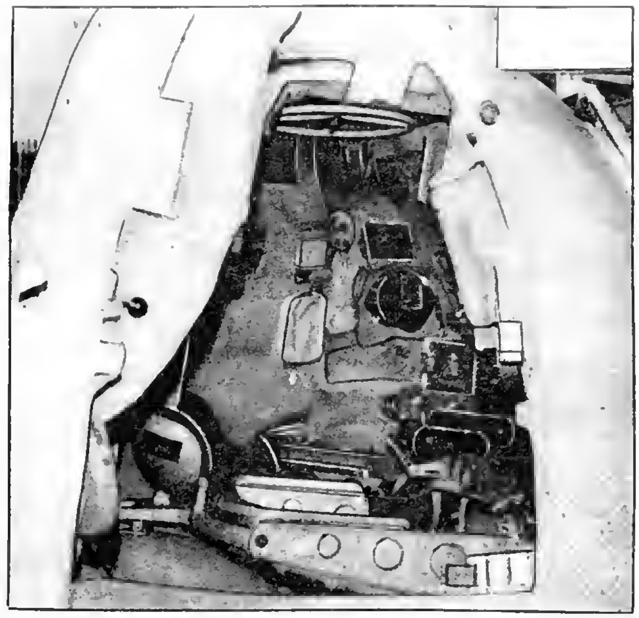
Orbital Research for the Indian Crew

Several medical, technological and Earth observation experiments were scheduled for the 7-day flight. The build-up and the flight itself were given exhaustive coverage by the Soviet media. The launch date and time were given in advance, as was the information for docking and landing. Launch was planned for 1308 on 3 April with docking at 1435 the next day; landing at 1050 on 11 April 60 km southwest of Arkalyk in Kazakhstan.

Of primary importance were sessions with the MKF-6M, KATE-140 and handheld cameras directed towards the Indian subcontinent. The Terra experiment was designed to help in the search for oil and gas bearing regions, the assessment of bio-productive areas around the Nicobar, Andaman and Laccadive islands and the mapping of the remote regions of the Himalayas and Karakorm region in order to assess ice melt and water run-off rates. Terra is part of India's preparations for the 1986 launch of its own remote sensing satellite, IRS, aboard a Soviet rocket. Salyut would make 11 passes over Indian terrain during the joint flight, the returned photographs requiring some 6-9 months to analyse.

Of the 12 joint experiments (out of a total of 43, some duplicated), the majority would be medical. In the Vektor experiment an Indian-made electrocardiograph would be used to study the cardiovascular systems of the cosmonauts. The joint crew would wear the Bracelet and Pneumatic devices from the start of the mission to attempt to arrest the flow of blood to the cranial regions. Once on the station, Atkov would supervise the medical check-ups three times a day. In 'Questionnaire and Poll' Sharma would answer a wide range of questions each day to assess his physical and mental adaptation to weightlessness. The Anketa and Optokinisis experiments were to study the relationships of the vestibular and visual systems of the cosmonauts during their adaptation.

In the most unusual experiment, Yoga, Sharma would adopt several positions (asanis) and his reactions would be monitored by the Miokomp and Briz devices as his muscles relaxed. Study of the locomotive system in this way would, according to Indian scientists, allow assessment of Yoga as a means of preventing the atrophy of muscles in space.



This Soyuz training simulator illustrates the cramped nature of the interior. This is a 1974 picture taken during training for the Apollo-Soyuz mission. *NASA*

Several materials technology experiments were planned, the most unusual of which would see the crew smelt 3 mm diameter silver-germanium alloy spheres (purity 99.99999%) and then spray the resulting combination, by means of the Evaporator-M instrument, onto a surface. The actual coating would occur in the ShK-1 airlock; some 200 examples of similar coatings had already been returned to Earth by previous Salyut crews for analysis.

The Indians also provided traditional food for the joint crew, such as curry, pineapple and mango juice, crisp bananas and mango fruit bars. These would supplement the traditional Soviet dishes on the station.

Tracking support for the flight would use the Soviet ground and sea-based tracking facilities in addition to a Soviet-equipped Indian facility at Kavalur.

Soyuz T-11 in Orbit

T-11's launcher was rolled out to the launch pad on 1 April. The crews had arrived from Moscow on 23 March, already in medical quarantine. On 2 April the Malyshev crew was officially named to make the flight.

Soyuz T-11 was launched at 1308:38 on 3 April into a clear blue sky, with live views being shown on Soviet and Indian TV. The first of two manoeuvres to put T-11 into a rendezvous orbit began at 1910 on the fourth orbit. Another manoeuvre on the next orbit completed the initial phase of the approach to Salyut and left T-11 in an orbit of 222 x 275 km; period 89.4 mins. Some 5,000 km separated the ship and Salyut 7. Sharma's work on T-11 involved the maintainance of communications and controlling the life-support systems.

The docking with Salyut's rear unit was again broadcast live and occurred at 1431:13 (some four minutes earlier than scheduled) on 4 April. The crew, call sign 'Jupiter,' moved into the station, to a warm greeting, at about 1740 after checking the airtightness of the seal.

Sharma brought portraits of India's political leaders (which were placed on the walls of the work compartment), an Indian national flag, emblems of the participating Indian agencies and a handful of soil from the Mahatma Gandhi memorial. One of the first acts was the formal exchange of telegrams between themselves and the

leaders of the USSR and India.

The first full working day for the six-man crew (the largest ever on a Salyut) began at 0600 on 5 April and lasted until 2000. The greater part of the day was devoted to medical research with Oleg Atkov supervising the work. Sharma conducted his first Yoga session. In addition, the crew exchanged the Soyuz T-10 and T-11 seats - the Jupiters were to return in T-10 and leave the fresher vehicle for the Mayaks.

In a 15 minute TV link-up with New Delhi, *via* FCC, Mrs Gandhi spoke to Sharma about the flight in both Hindi and English. Sharma told her that India looked very beautiful from orbit and that the mock-up he had trained in was just like the real thing.

On 6 April they began the photography of India. Kizim controlled the station's attitude while the others used the fixed and handheld cameras to shoot a large number of pictures of areas around the Indian subcontinent during three orbital passes. Simultaneous photography and ground-truth data were being collected by Indian and Soviet specialists from aircraft and ground-based vehicles. In the afternoon the medical experiments were continued.

On 7 April there were further medical tests, photography and the Evaporator M was used to coat materials. In three TV sessions the cosmonauts answered questions put to them by journalists in the large press corps at FCC. In one exchange Sharma was asked if his snoring was keeping the others awake at night! Sharma referred the question to his wife.

On 8 April the cosmonauts radioed an urgent warning to FCC regarding a 50 km^2 forest fire they had spotted in Burma. The photography of India was continued with some 2,000 individual pictures having been taken with the MKF-6M. About 40% of India would be covered. Weather information was passed on to FCC by the Indians using the Insat 1B satellite to obtain weather images (the Soviets do not possess such a satellite in geostationary orbit). The weather remained good over India for the mission.

FCC reported on 9 April that the crews had asked for additional work because they had already accomplished more tasks than envisaged. The day's photography of India saw the cosmonauts skip breakfast to accomplish it. In the afternoon, in addition to their regular medical work, they continued making a documentary film which they were filming to a pre-prepared script written by a top Soviet screenplay writer and director.

The coverage of India was completed on 10 April and they began loading the film and other results of the flight, and the long-stay crew, into the Soyuz T-10 descent cabin. A test of Soyuz's engines was conducted. Atkov told FCC that all the cosmonauts, himself included, were in "marvellous shape."

The Jupiters' Return

The crews were awake early on 11 April in preparation for the departure. Before leaving, Malyshev, Strekalov and Sharma gave blood for tests of its salt content. After an emotional farewell the Jupiters sealed themselves in T-10 and, at 1133, undocked from the front of Salyut.

The descent cabin touched down at 1050 some 56 km east of Arkalyk in a ploughed field which still had frost in the furrows. The cabin came to rest on its base and reporters were quickly on the scene. After being helped out, the Jupiters were seated in special chairs where they answered questions from reporters. Later, they signed their autographs on the descent module.

They had returned with some 1,000 complete sets of MKF-6M photographs of India, 200 large-format KATE-140 pictures and several hundreds of handheld photographs. The Soviets noted that the Jupiters had almost exhausted Salyut's film stock during their flight.

Soyuz T-11 Redocking

Once the Jupiters had returned to Earth Soviet coverage of the long-stay mission returned to normal.

On 13 April, in order to free the docking port at the rear for a new Progress cargo craft, Soyuz T-11 was redocked at the front of the station. At 1027, after the Mayaks had sealed themselves into T-11, the craft was undocked from the rear port and backed away. The station was turned automatically so that T-11 could be manoeuvred to a docking at the front; the Mayaks then reentered Salyut to continue their flight.

A new Progress cargo ship was launched at 0813 on 15 April and successfully docked with Salyut's rear unit at 0922 on the 17th.

To be continued

Acknowledgements

The writer would like to thank the Novosti Press Agency and the Press and Information Section of the High Commission of India.

FROM THE SECRETARY'S DESK

Grist for the Mill

I was happy to see that the Council has decided to hold the 1985 subscriptions at the same rates for another year, which now makes it three in a row.

Balancing the budget must have been very difficult, especially when the 5% annual increase in printing costs, alone, adds up to another £1 per member per year. If we add the other items which have increased over this period, the saving per member must be of the order of £6-7, quite a substantial sum.

Thanks are due to every member who helps to keep our costs down. They deserve a large part of the credit. Others who would like to help will find some ideas in the subscription notice.

For convenience, these are summarised below:

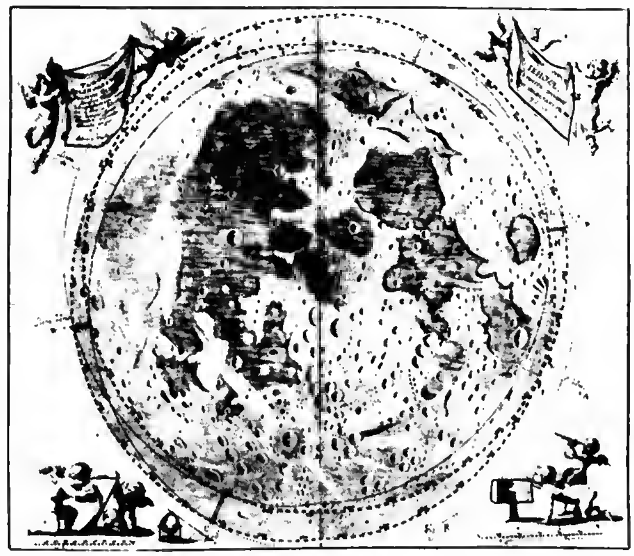
1. *Pay by Direct Debit.* This simple form takes all the aggro out of subscription collection, one of the most expensive areas. Direct Debits are intended for regular payments but can easily include a modest annual donation as well, if desired.
   Those who haven't completed a Direct Debit should be sure to pay accounts promptly and in full before Derember 31st. Try to avoid the need for frequent reminders or, even worse, the preparation of individual letters to try to get matters right.
2. *Deeds of Covenant.* This is another simple form which applies to all members who pay UK tax. It doesn't involve the member in any additional outlay whatsoever, yet benefits the Society considerably.
   Those who have completed *both* Direct Debits ano Deeds of Covenant may wear their halos with becoming modesty.
3. *Introducing new members.* Don't hide your light under a bushel when it comes to this. The Society has a lot going for it, a great history to be proud of and a programme which is both ambitious and constructive and magazines which are well worth having. Back-up material can be sent either direct to each potential new member or to yourself, with batches of magazines for special occasions. One of our greatest source of pride is the number of members who join for life. It's the finest recommendation of all.

Hevelius

We have just acquired a very interesting book by Hevelius, published in 1654, on the libration of the Moon. The Moon's libration in longitude (i.e. the fact that the Moon "sways" so that a little more of the Eastern or Western edges can be seen more at one time than another) was discovered by him in 1647. He was actually the first astronomer to give much attention to the Moon, his *Selenographia* (published in 1647) providing a detailed description and including one lunar map and 40 charts. At that time the main lunar features were not named - this wasn't done until four years later when Riccoli's map did this for the first time.

Unfortunately, our copy is minus its map of the Moon though we have been able to obtain a photographic reproduction from the Royal Greenwich Observatory, thanks to Janet Dudley the Librarian-cum-Archivist, and which we reproduce just in case the original reappears one day to make our volume complete!

Hevelius, in Danzig, continued his work, observing the comet of 1652, the transit of Mercury in 1661 and publishing his *Cometographia,* a Star Catalogue and an Atlas, as well as observing the variable star Mira Ceti and chewing the cud, sometimes not altogether happily, with other leading astronomers of the day.



Wants

Can anyone help us to obtain pictures of comets, meteors and asteroids? Have readers any prints they would be willing to make available to help meet some of our future publications commitments?

These are a few examples of problems we meet in our daily round to get magazines out on time and with interesting material. The picture problem can prove very irksome, particularly when we need them at short notice and lack time to hunt them down.

Welcoming Overseas Visitors

We adopt a suitably welcoming stance to overseas members taking the opportunity, when visiting the UK, to call in to see us, particularly where they have given us prior warning.

Most enjoy their call and take the opportunity to find out as much as they can about current happenings in the Society, to feel our pulse, so to speak, and then leave suitably fortified. Many use the occasion to interview us for magazines "back home," to take photographs or make recordings, or even simply to purchase souvenirs.

It is this last which has always bothered me. The Society has a large range of saleable items, attractive and reasonably priced, but I've always felt that members who come from afar ought to have something more personal to record their visit. Dimly, in my mind, I've imagined giving them a nicely-produced booklet with information

about the Society's history, its offices and the people who work in them and with space in the front to record the visit itself.

I'll have to do it one of these days.

Too Much

The Editorial on the world population explosion mentioned in *Spaceflight* for June brought to mind an earlier occasion when this arose. It was a Society Discussion meeting many years ago. I had been invited to speak, along with Les Shepherd and Arthur Clarke, with the late Val Cleaver in the Chair. My contribution was to be on the relevance of space to the world population problem, including such telling remarks as 'by the year 2000 there will be more people alive than the total of all who have lived and died since man began. Whether this was true or not I didn't know, but it sounded good. I had also culled plenty of other facts from a Report on the same problem, so was well placed to do my stuff.

Les and Arthur had an easy ride but, when it came to my turn, Val Cleaver decided to use his Chairman's prerogative to launch into a speech all his own. Unfortunately, he chose to talk about the world population problem, mentioning all the points I had laboriously collated. Having exhausted the subject himself, I was then invited to give my maiden talk to the Societyl

I had to apply a lesson in mental agility learned long ago. This initial baptism took place at an inaugural BIS meeting in 1945. The topic was the Society's proposed Constitution, another item prepared after long labour. My brief introduction was followed immediately by a long commentary, peppered with questions, from the Society's then President, Professor A.M. Low. He spoke for nearly an hour and then everyone looked to me for reply.

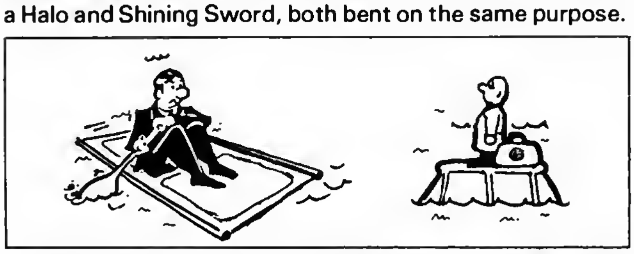
Unfortunately, I had forgotten everything except his last question - so I dealt with that and, in a sudden burst of honesty (or subtlety, as the others had it later) admitted that I had forgotten the others and would the Professor kindly repeat them?

He had to admit that he had forgotten them tool

The Constitution was then adopted, with barely another word.

The Wet Look

We were pleased to learn that flood barriers on the River Thames are now fully operational. Every so often in the past we had to endure a "flood alert" - with the aim of adding this particular anxiety to fire, lightning, subsidence or a Visitation by a Fallen Angel or one with a Halo and Shining Sword, both bent on the same purpose.

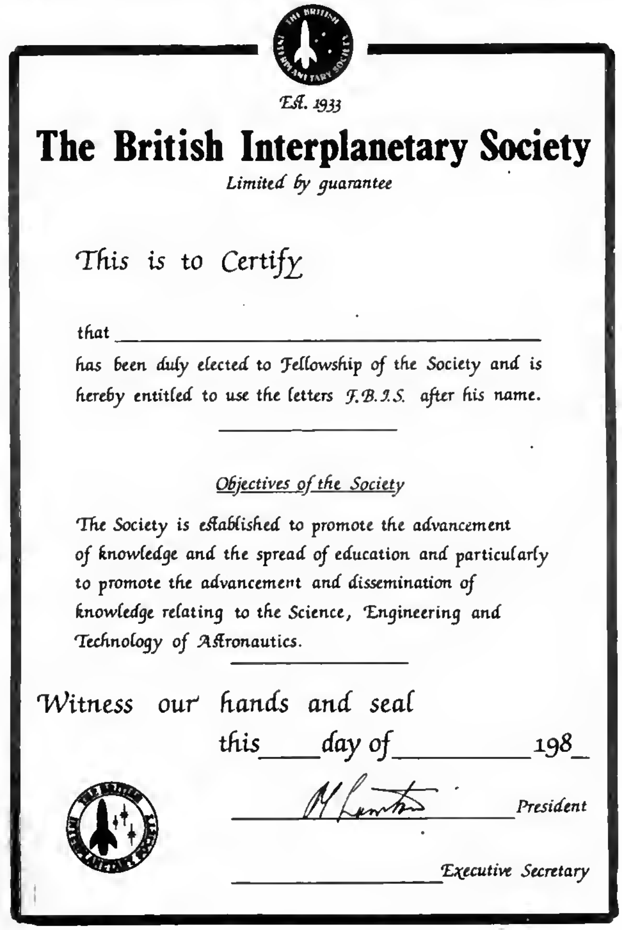


In all truth, Thames' Floods seemed to occur very rarely so we were comforted by the fact that we probably passed the danger mark for this century a few years ago. This was while we were at our Bessborough Offices. A look at the river then, not more than a couple of hundred yards away, induced quite a shock. The water level was only a few inches below the tops of the parapet and way above road level. Had the parapet given way, the whole district would have gone under leaving us peering out from our first floor windows on a surrounding lake.

Membership Certificates

Over 500 Fellows have so far requested prints of the new de luxe Fellowship certificates which, printed in three colours, depict the Society's new seal and are eminently suitable for display. In view of this popularity the Council has decided that a similar certificate should be prepared for Members. The size is 30 x 42 cm: a reduced version is reproduced below.

The new certificates (for both Members and Fellows) are available at £5 ($8) post free. Since all of the certificates are inscribed by hand, some delay will neccessarily occur between placing an order and receiving the certificate but this will not, normally, exceed one month.



Est. 1933

The British Interplanetary Society

Limited by guarantee

This is to Certify

that ______________________

has been duly elected to Fellowship of the Society and is hereby entitled to use the letters F.B.I.S. after his name.

Objectives of the Society

The Society is established to promote the advancement of knowledge and the spread of education and particularly to promote the advancement and dissemination of knowledge relating to the Science, Engineering and Technology of Astronautics.

*Witness our hands and seal this ____ day of __________ 198_*

______________ *President*

______________ *Executive Secretary*

Secret of Success

A correspondent wonders how we manage to get our multitude of tasks done. The secret lies in making sure that each task is recorded on scrappy and incredibly dirty pieces of torn-off paper.

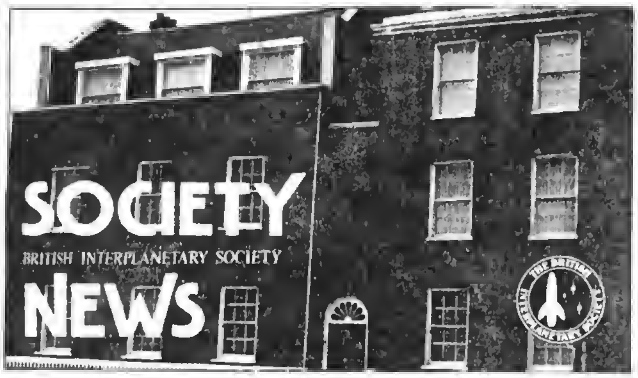
These are so foul, frustrating and annoying and hated so much that I get intense satisfaction in consigning each in turn to oblivion.

Those that remain continue to reproach me and spur me on to get rid of them too. Hence, all the jobs get done.

The Dead Zone

I was intrigued to see that a recent film was entitled *The Dead Zone*. I have the same problem. An example occurred when a press cutting fell out of an envelope the other day. It proved to be an extract from the *Radio Times* of 1950, listing a programme to be broadcast on the BBC Home Service on 1st April (note the day). It was actually a recording on "Interplanetary Travel" given by Dr. Les Shepherd, the late Val Cleaver and myself.

I can't remember anything about it.



BANGING THE DRUM

More Publicity for the Society

It is most important for our Society to achieve continuing, even if small, publicity, for this tranlates into more of an influx of new members than does a relatively large "splash" and underlines the fact that efforts by individual members, many of which are described below, represent the most effective way of putting the Society across.

Newspapers and Magazines

The Washington Post of 5 February, in an excellent article called "Starships to reach our Galactic Brethren," mentioned the Society several times and included a large artist's representation of Daedalus. A number of our American members noticed this and brought it to our attention.

The *San Diego Tribune* of 18 November 1983 under a Books/Writers heading concerned itself with Curtis Peebles' new work and mentioned both that he wrote articles for *Spaceflight* and the name of the Society.

Magazines went even further. *Astronomy* for October 1983 ran its main article as "Daedalus: Design for a Starship," supported subsequently with the appearance of a letter from our Executive Secretary mentioning later work published in the "Red Cover" issues of *JBIS* and offering to send specimens to interested readers. *Sky and Telescope* for February 1984 provided a Report on our 50th Anniversary meeting while Frank Winter, in a series called "Out of the Past" in *Aerospace America,* reproduced a copy of the front cover of *JBIS* dated January 1934.

Bill McLaughlin sent us an example of how publicity for the Society can be obtained in other ways, in this case by including in his biography accompanying text in *Interdisciplinary Science Reviews* an excellent reference to his "News from JPL" which appears in *Spaceflight*. He added that inclusion of papers under "References" at the end of articles by members also provides very useful publicity.

Rather unexpectedly, the *Daily Telegraph* of 14 October 1983 extracted a piece from the "Secretary's Desk" in *Spaceflight*, no doubt to the amusement of many of its readers. This described our Executive Secretary's reply to the globally-feared drowsiness syndrome, which took the form of firing a starting pistol into the ear of offenders at the first sign of dropping off.

Books

Publicity for John Macvey's new book *Where Will We Go When The Sun Dies?* included a reference to his connection with the Society, while "Space Exploitation" by Tim Furniss went even further. It included not only the Society's address but positively advocated readers to join. Chris Allen drew our attention to a 1982 book on UFO history which, surprisingly, contained a reference to the BIS. This related to a Brains Trust meeting held on 5 March 1948 when the matter of UFOs was discussed. So, after 35 years, a BIS Brains Trust got a mention in the UFO anthology!

Radio

Radio and TV coverage was virtually non-existent on practically everything to do with space. This prompted Andrew Sinuks to advocate that the Society orchestrate a protest to try to alter the position. Unfortunately, TV channels are inured to pressures of this sort, having endured it many times before from activists in other fields. They much prefer "individually-composed letters from the heart" so members would be well advised, instead of writing to the Society, to write direct to those who are best placed to use such complaints e.g. Points of View, *The Listener*, BBC's *Radio Times* and ITV's *TV Times*. Any letters which appear or publicity which accrues reach a much wider audience than is possible through our Society alone.

On the otherhand, the TV Teletext service gives detail of the Society; so does British Telecom's "Space Line," so there is a slight plus in this area.

Displays

Displays organised by individual members probably do most to promote the Society. John Burley, for example, put on another "Spaceflight Extravaganza" at Exeter on 9 March, during which he publicised the Society. William Ganoe in Tucson did the same in July, using Society material for "Space Week 84." Steven Newport made up a number of diplay items, using much of the Society's material, for use in local Libraries, all this being rounded off by a request in from the new Aerospace Museum at the California Museum Science and Technology in Los Angeles to reproduce some of the Society's material.

We invariably send a goodly number of our new flyers (membership brochures) on the Society to those putting on displays. These are easy to handle and give a good deal of background information as well as including an application form. They easily insert into envelopes e.g. when sending out circulars for other purposes. This fact was put to good use by Dr. Bob Forward who sent out 300 of them last January and by Fred Becker who collected 100 the following month for the same purpose.

Other members might like to make a note of this. It's a very good and a cheap way of getting the name of the Society to likely new members without any fuss or bother.

We extend our heartiest congratulations to astronautics pioneer Prof. Hermann Oberth on his 90th birthday. Born on 25 June 1894, Prof. Oberth has been a BIS Fellow for many years.

LIBRARY REPORT

Books

Acquisitions for the Library have continued to progress, slowly but nonetheless in the right direction.

Our present stocks are:

	At 19. 7. 1984	At 31. 8. 1983
Books	2440	2278
Reports	4496	4281
	6936	6559

Much credit is due to those members who toiled long and hard to make sure that we were well supplied. For example, a selection of books arrived from Professor Groves together with a small mountain of technical reports. Rolf Engel provided not only a Catalogue of Galaxies and Clusters of Galaxies (in six large volumes), which we were delighted to have, but also went to considerable trouble to supply a copy of his book *Moskau militarisiert den Weltraum.* Rob Staehle provided an excellent package of reports and similar data while another of our American members, Harold Bates, dedicated himself wholly to the task, not only by sending us a large selection of books and charts for us to keep but adding to this with package after package of items for us to *sell.* One can only assume that he must have denuded his house completely.

Others weighed in as opportunity allowed. Horace Dall provided a long-wanted copy of *The Story of the Comets* by G.F. Chambers and two rare volumes of *System of the World* by Laplace. Dr. Allyn Tennant presented a copy of a *Catalogue of Bright Reference Galaxies,* Desmond King-Hele a number of old ESRO reports and D. Lago did the impossible by locating a copy of Vol 2 of *Men in Space* to help augment our set of this long-wanted series.

John Davies had the cheek of the Devil. He saw a book being used as decoration in a bookcase in a furniture showroom and, without more ado, went inside to ask if they would be willing to give it to our Library. He got it, too!

Yvonne Cooper found a very sleek, glossy coffee-table book called *Our Gagarin* that had somehow earlier slipped through our fingers, while Curtis Peebles produced a gift copy of his book *A Battle for Space* and Captain Joseph Bassi found *We Seven,* one of the books we have long wanted. To these, and to the many other members who have continued to act as our eyes and ears in locating works to augment our Library, we send our grateful thanks.

THE POSTMASTER GENERAL
Washington, DC 20260-0010

April 19, 1984

Dear Mr. Carter:

Enclosed ia a philatelic cover which I am presenting to your Society. Please accept it with my compliments on behalf of the United States Postal Service, and congratulationa on the celebration of the Society's 50th anniversary.

The cover was carried aboard the Space Shuttle Challenger during its mission August 30 - September 5, 1983. Over a quarter million serially numbered covers were launched aboard Challenger in a cooperative effort between the U.S. Postal Service and the National Aeronautics and Space Adminiatration. Covera numbered 0 through 1,000 were carried in the crew cabin, and the enclosed cover ia one from this series. The covers that were sold to collectors were atored in the giant cargo bay of the ahuttle and were exposed to the extreme conditions of the apace environment.

Further details on the flight can be found in the enclosed folder which features a dramatic photograph of Challenger taken at night while being readied for launch.

I trust the viaitors to your permanent diaplay of apace covers will enjoy viewing thia cover for many years to come.

Sincerely,

William F. Bolger

Encloaure

Mr. L. J. Carter
Executive Secretary
Britiah Interplanetary Society
27/29 South Lambeth Road
London SW8- 1SZ
ENGLAND

A cover carried aboard Shuttle *Challenger* was a recent valuable addition to our collection.

Artefacts

We have long pondered over the question of 'When does a selection become a collection?' The reason for this is that, though we continue to accumulate odds and ends, very little so far actually ranks as a collection in its own right. The only exception to this, possibly, are the First Day Covers on astronomy and space topics. We have accumulated about 300 so far, though the number being currently produced far exceeds our collection rate with the result that our list of missing items grows longer by the hour!

Some idea of the scope of this can be gained by the fact that two collections were on the market recently, one pre-war and one post-war. Neither was complete yet the total value envisaged for them was of the order of £30,000.

However, our own collection continues to grow satisfactorally. Three covers came from Rex Turner and another three on Apollo 13, from Neil Kroschel, while Dale Kornfeld continued to post covers to us (we wish many more members would do this as opportunity arose). Roger Wheeler offered us a large packet containing a number of FDCs, adding two patches and some small artefacts. Peter Jones augmented previous gifts by providing more First Day Covers while Pete Molton, holding firmly to the belief that we ought to know what we were doing, took the trouble to purchase a space FDC catalogue for us in support of his thesis that members ought to consider buying books for the Library and then donating them - having settled with us beforehand the titles we desire.

Dwarfing all these was a magnificent gift of four volumes containing what is probably a complete set of all ESA-related FDCs to date, presented by Liliane Valentin, Secretary of the Estec Philatelic Society. This was a really magnificent gift for which the Society is extremely grateful.

A fine batch of FDCs arrived out the blue from Nicholas Barnes. He had started collecting them some time ago and, having decided that the Society now offered a better "home," brought them along. They were particularly welcome as they included a number of early covers.

Mitch Sharpe gave us some Soviet badges and Peter Jones came in again with a small plaque depicting the ASTP project. Captain Bob Freitag added an Apollo 11 menu, which was fascinating, while Carey Cheshire presented a large print of Shuttle *Enterprise* flying over

WANTED

We would like to obtain a brass Gregorian telescope for display in the Society's offices. If any member finds one for disposal, please secure a "hold" on it and let the Society know at once.

Stansted which we have now framed and put in our Reception area for all to see. Fred Durant must have raided his own Christmas Tree for included in one package was a tiny Hohner harmonica, identical to that carried aboard the Gemini 6 flight in December 1965 when Wally Schirra played 'Jingle Bells.' The original harmonica is now in the National Air & Space Museum in Washington, D.C.

Bill McLaughlin stood no nonsense. His wife, Karen, due to go on a trip to the USSR, must have been well-instructed about Library needs, perhaps to the exclusion of all else. In any event, she returned with a goodly collection of items.

Two video disks were graciously presented by the Jet Propulsion Laboratory through the good offices of Burt Edelson, to which we can add a set of slides and a tape from John Fairweather and yet another tape on space sounds from Roger Wheeler.

We didn't do too well on the coins and medals side. The only response was a letter from Dr. Archenhold saying that his father, the founder of the Treptow Observatory in Berlin, had had a comet medallion struck on the occasion of the 1910 Halley's Comet return. It showed Halley's picture on one side and the Treptow Observatory with the comet's path on the other. Unfortunately, he hadn't got such a medallion and could we help him obtain onel

There also appears to be a medallion issued in honour of Professor Oberth some time ago. Strangely enough, Professor Oberth gave a public lecture in the Treptow Observatory in the 1920's.

It would be nice if our "local" collection included a souvenir of the once-famous 18th Century Vauxhall Gardens, the entrance to which was just a few hundred yards along the road from our present offices. Presumably such things come on the market, occasionally. If any members come across such items, please tell us.

We have been told that, in the UK alone, there are now about 20 museums interested in collecting and exhibiting space items, presumably all either with money to spend or clout to wield in order to get them.

This will put us at the bottom of the queue unless the goodwill of members and others helps us to obtain such items. It certainly looks as though we will need to rely very much on our own devices from now one.

Library Sales

Our current aim is to secure a collection of books which have fostered interest in outer space from early times. This would include early SF works such as Bishop Godwin's *Man on the Moone*, texts on pyrotechnics (now very hard to come by) and a range of popular and technically significant works that helped both to create interest in and to provide an understanding of space problems. Some nearer our own times are books on 18th and 19th century comets, eclipses etc and ending with some of the SF magazines from the 1920's which did much to foster interest in the exploration of the Solar System. Mr. Scorah has kindly helped us out with some of the last items while Captain Bob Freitag produced a photocopy of a book by von Schorndorff containing 16th century plans for building multi-stage rockets. Only four copies of this book are in existence, one original being presented by Aerojet-General to the Huntington Library in San Marino, California recently.

How far we progress along such ambitious lines has yet to be seen, though we were fortunate enough recently to acquire the book by Hevelius on the *Libration of the Moon*. If funds permit, we might be able to get more items of this nature.

RAISING FUNDS FOR THE FUTURE

The Council ensures that members' subscriptions are spent on giving an excellent return by way of publications and meetings and in covering essential running costs. Our Accounts confirm this is how subscriptions are fully used, but it leaves nothing over. For everything else, including future Society growth, everything depends on reaching our capital programme targets. The acquisition of the word processors and supporting equipment last year was just one example; an extension to our Conference Room could be another.

No member has to pay extra for such things. Rather, the Council keeps subscription rates at the lowest practicable level so that few interested are debarred because the Society is financially out of reach. Membership rates have not even risen with inflation, a measure of success in keeping costs down.

However, with little or no surplus available from subscriptions, the Society has to undertake a variety of fund-raising tasks to accomplish its aims for capital projects. These extra activities are of great importance and include many ways where members can help. For example, one way that costs nothing at all is for those who pay UK income tax to complete a simple Deed of Covenant (obtainable from the Society on request) and so enable us to claim a tax refund. Last year this came to £2,600. Prompt payment of subscriptions, thus cutting down on the expense of reminders, also helps, even more so if a Direct Debit form is used.

Other members, as their spirits and finances allow, can contribute to our Development Fund, either when remitting their annual dues or in the course of the year. Yet another way arises in acquiring some of the saleable items which the Society promotes. These are excellent value: the profits made last year covered much of the cost of our word processing equipment. Sales of surplus Library books - even though offered at bargain prices - also create funds, in this case to help us expand our Library.

We organise special activities to provide funds for specific purposes. Our 50th Anniversary banquets, for example, helped to cover the cost of carpeting the Conference Room. We hope that Space '84 will help us acquire the modular display stands we want.

Occasionally, but all the more welcome for that, are gifts from members to help us buy a particular item, whether this comes in the form of cash or kind.

We have seen many times the pleasure members get when they come to HQ and see what we have accomplished. We feel sure that those who help us carry this work even further will find it a very rewarding experience.

DESIDERATA

Below is a list of books we are currently seeking for our Library. Any members able to secure copies for us are asked to contact the Executive Secretary.

Rocket Propellant Handbook, B. Kit and D.S. Evered, 1964, MacMillan & Co (NY).

Mass Motions in Solar Flares & Related Phenomena, Ed. Y. Ohman, 1968, MacMillan & Co (NY).

A Source Book in Astronomy & Astrophysics 1900-1975, Ed. K. Lang and O. Gingerich, 1979, Harvard Univ. Press.

Solar Flares, Ed. A.A. Sturrock, 1980, Colorado Assoc. Univ. Press.

The Solar Atmosphere, H. Zirin, 1966, Blaisdell Pub. Co. (Divn. of Ginn & Co.).

SATELLITE DIGEST -176

Robert D. Christy

Continued from the July/August issue

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

COSMOS 1542 1984-25A, 14793

Launched: 0800, 7 Mar 1984 from Tyuratam by A-2.
Spacecraft data: As Cosmos 1537.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 348 x 414 km, 92.21 min, 70.35 deg.

COSMOS 1543 1984-26A, 14797

Launched: 1700, 10 Mar 1984 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Vostok manned craft with spherical re-entry module, instrument unit and a cylindrical supplementary payload at one end. Length about 6 m, diameter 2.4 m (max) and mass around 6000 kg.
Mission: Military photo-reconnaissance, recovered or re-entered after 26 days.
Orbit: *216 x 394* km, *90.62* min, *62.82 deg.*

COSMOS 1544 1984-27A, 14819

Launched: 1706, 15 Mar 1984 from Plesetsk by F vehicle.
Spacecraft data: Not available.
Mission: Possibly electronic reconnaissance.
Orbit: 634 x 664 km, 97.77 min, 82.55 deg.

EKRAN 12 1984-28A, 14821

Launched: 1401, 16 Mar 1984, from Tyuratam by D-1-E + apogee motor.
Spacecraft data: Cylinder with a pair of boom-mounted solar panels and a flat aerial array at one end. Length 5 m, diameter 2 m and mass in geostationary orbit 2000 kg.
Mission: To transmit programmes of Central Television to collective receiving aerials in remote areas.
Orbit: Geosychronous above 99° longitude.

MOLNIYA-1(60) 1984-29A, 14025

Launched: 2330, 16 Mar 1984 from Plesetsk by A-2-e.
Spacecraft data: Cylindrical body housing instrumentation and the payload, surmounted by a conical motor section. Power is provided by a 'windmill' of six solar panels, overall length 3.4 m, diameter 1.6 m and mass around 1800 kg.
Mission: Communications satellite providing telephone, telegraph and TV signals through the 'Orbita' system.
Orbit: Initially 621 x 40,573 km, 734.86 min, 62.85 deg, then lowered to 620 x 39,766 km, 718.42 min, 62.86 deg to ensure daily ground track repeats.

COSMOS 1545 1984-30A, 14849

Launched: 1105, 21 Mar 1984 from Plesetsk by A-2.
Spacecraft description: As Cosmos 1543.
Mission: Military photo-reconnaissance, recovered after 15 days.
Orbit: 356 x 415 km, 92.30 min, 72.83 deg.

COSMOS 1546 1984-31A, 14867

Launched: 0553, 29 Mar 1984 from Tyuratam by D-1-E + apogee motor.
Spacecraft description: Possibly similar to Ekran 12 but with a smaller aerial array and the solar panels attached to the body.
Mission: Possibly related to the development of the 'Luch' communications satellites series.
Orbit: Geosynchronous above 23 deg west longitude.

SOYUZ T-11 1984-32A, 13872

Launched: 1309*, 3 Apr 1984 from Tyuratam by A-2.
Spacecraft description: Near-spherical orbital compartment, conical re-entry module and cylindrical instrument unit with solar panels. Length approx 7.5 m, diameter 2.2 m and mass around 7000 kg.
Mission: Carried visiting crew of Yuri Malyshev, Gennady Strekelov and Indian cosmonaut Rakesh Sharma to Salyut 7. The vehicle docked with the rear port of Salyut 7 at 1435, 4 Apr. The crew returned to Earth in Soyuz T-10, landing at 1050, 11 Apr. On 13 Apr at 1027, the resident Salyut crew undocked Soyuz T-11 from the station, waited while Salyut completed a 180° rotation and re-docked at the forward port, to permit further Progress dockings.
Orbit: Initially 196 x 223 km, 88.62 min, 51.63 deg, then manoeuvred to 227 x 271 km, 89.42 min while chasing Salyut before docking at 284 x 296 km, 90.25 min, 51.62 deg.

COSMOS 1547 1984-33A, 14884

Launched: 0140, 4 Apr 1984 from Plesetsk by A-2-e.
Spacecraft data: Possibly similar to Molniya.
Mission: Missile early warning satellite.
Orbit: Initially 582 x 39,221 km, 706.63 min, 62.83 deg, then raised to 603 x 39,743 km, 717.60 min, 62.90 deg to ensure daily ground track repeats.

STS 41C 1984-34A, 14897

Launched: 1359*, 6 Apr 1984 from the Kennedy Space Center.
Spacecraft data: Shuttle Orbiter *Challenger*.
Mission: Eleventh Shuttle flight, carrying crew of Robert Crippen, Francis Scobee, Terry Hart, George Nelson and James van Hoften. The primary task was to capture and repair the Solar Maximum Mission satellite (1980-14A). On 8 April, Nelson failed to dock his manoeuvring unit with the satellite - the manoeuvre had been intended to reduce SMM's spin and bring it into the cargo bay. On 10 April, it was captured using the remote manipulator arm and placed in the bay for Nelson and van Hoften to repair during an EVA on 12 Apr before being returned to orbit the same day.
Orbit: Initially 218 x 465 km, 91.18 min, 28.51 deg then by several manoeuvres to 493 x 498 km, 94.34 min, 28.51 deg.

LDEF 1984-34B, 14898

Launched: 7 Apr 1984 from cargo bay of *Challenger*.
Spacecraft data: Twelve-sided prism, 9.1 m long, 4.3 m diameter with mass 9707 kg.
Mission: To provide samples of materials, electronic systems and scientific packages with a prolonged period of space conditions. LDEF (Long Duration Exposure Facility) is due to be retrieved from orbit during an STS mission in early 1985.
Orbit: 477 x 479 km, 93.98 min, 28.50 deg.

CHINA 15 1984-35A, 14899

Launched: 1100, 8 apr 1984 from a new Chinese launch site by Long March 3.
Spacecraft data: Not available.
Mission: Communications satellite test.
Orbit: Geosynchronous near 125 deg east longitude.

COSMOS 1548 1984-36A, 14902

Launched: 1400, 10 Apr 1984 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1543.
Mission: Military photo-reconnaissance, recovered or re-entered after xx days.
Orbit: 167 x 334 km, 89.53 min, 67.15 deg, manoeuvrable.

OPS 7641 1984-37A, 14930

Launched: 14 Apr 1984 from Cape Canaveral AFB by Titan 34D.
Spacecraft data: Not available.
Mission: Possibly a missile early warning satellite.
Orbit: Geosynchronous.

PROGRESS 20 1984-38A, 14932

Launched: 0813, 15 Apr 1984 from Tyuratam by A-2.
Spacecraft data: Similar to Soyuz T-11 but lacking solar panels and with the recovery module replaced by a compartment housing propellant tanks.

Mission: The delivery of consumebles and other materiels to Salyut 7. Progress docked with the rear port of Selyut 7 at 0922, 17 Apr, and efter unloeding wes undocked at 1746, 6 Mey 1984. It wes commanded to re-enter the atmosphere on 7 May.
Orbit: Initially 186 x 260 km, 88.89 min, 51.60 deg, then by wey of a 232 x 276 km trensfer orbit to the docking with Salyut in en orbit of 284 x 326 km, 90.56 min, 51.64 deg.

OPS 8424 1984-39A, 14935

Launched: 17 Apr 1984 from Vandenberg AF8, possibly by Titan 38-Agena D.
Spececreft date: Not available.
Mission: Probebly military photo-reconneissence.
Orbit: 127 x 311 km, 88.90 min, 96.40 deg.

COSMOS 1549 1984-40A, 14938

Launched: 1140, 19 Apr 1984 from Plesetsk by A-2.
Spacecraft date: As Cosmos 1543.
Mission: Militery photo-reconnaissance, recovered efter 14 days.
Orbit: 356x415 km, 92.30 min, 72.90 deg.

GORIZONT 9 1984-41A, 14940

Leunched: 0418, 22 Apr 1984 from Tyuratam by D-1-E + apogee motor.
Spececraft data: As Cosmos 1546.
Mission: To provide telephone, telegraphic and TV communications both within and outside the USSR.
Orbit: Geosynchronous ebove 53 deg east longitude.

PROGRESS 21 1984-42A, 14961

Launched: 2247°, 7 Mey 1984 from Tyuratam by A-2.
Spececreft deta: As Progress 20.
Mission: The delivery of consumables, including propellants end equipment to Salyut 7. Progress docked with the rear port of Selyut at 0010, 10 May, end efter unloading was undocked et 1041, 26 May. It was commended to re-enter the atmosphere later that dey.
Orbit: Initially 190 x 243 km, 88.76 min, 51.63 deg then by way of a 243 x 277 km transfer orbit to the docking with Salyut in an orbit of 276 x 316 km, 90.37 min, 51.61 deg.

COSMOS 1550 1984-43A, 14965

Launched: 0618, 11 May 1984 from Plesetsk by C-1.
Spacecraft deta: Cylindrical body with domed ends, enclosed in a drum-shaped solar arrey with length and diameter both about 2 m, and mess around 700 kg.
Mission: Navigation satellite.
Orbit: 976 x 1071 km, 105.4 min, 82.98 deg.

COSMOS 1551 1984-44A, 14967

Launched: 1300, 11 May 1984 from Plesetsk by A-2-e.
Spececreft data: As Cosmos 1543.
Mission: Military photo-reconnaissance, recovered after 12 deys.
Orbit: 196 x 279 km, 89.29 min, 72.89 deg, manoeuvreble.

The Future for Space Technology
G.K.C. Pardoe, Frances Pinter (Publishers) Ltd., 5 Dryden Street, London WC2E 9NW, 206pp, 19B4, £14.95.

The main theme of this book is to look ahead towards the beginning of the next century and to explore the many ideas and projects in space which are either being developed now or are currently contemplated.

One important message which comes through is that, while basic research remains as important as ever and space science, particularly in astronomy, possesses tremendous scope, space is already a very commercial business and becoming more so as time passes. Many industries and business which so far have had nothing to do with space will be users and contributors in the future.

This book is designed to alert the full spectrum of the community to future space opportunities and to show how individuals should or could be involved.

Materials Processing in Space
Ed. B.J. Dunbar, American Ceramic Society, 65 Ceramic Drive, Columbus, Ohio 43214, USA., 343pp, 19B3.

This is a compilation of papers from a special conference on materials processing in space held at the American Ceramics Society B4th Annual meeting and comprising the fifth volume in a series under the title of "Advances in Ceramics."

The volume is an introduction to the study of materials processing in space but it also provides an overview of the space shuttle system, together with avenues for experimentation and a theoretical consideration of liquid forces in micro-gravity.

Subjects covered include glass processing and glass melting in a micro-gravity environment, containerless processing, bubble behaviour, semi-conductor crystal growth, together with reviews of past, present or future tests and proposed experiments conducted in the space environment.

The micro-gravity environment of space offers special advantages in studying physical and chemical phenomenon in preparing materials not easily produced in the gravity field of the Earth. The space advantages include e.g. the absence of thermal and solutal convection and sedimentation, the containerless processing which eliminates contamination and a lack of hydrostatic pressure effects and deformation at high temperatures.

Areas of science already benefitting from space studies include continuous flow electrophoresis, semi-conductor technology and crystal kinetics.

The History of Astronomy from Herschel to Hertzsprung
D.B. Hermann, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambride CB2 2RU, 220pp, 19B4, £12.50.

The foundations of astronomy today were laid during the golden age between 17B1 and 1930 i.e. between finding the planet Uranus and the discovery of the expansion of the Universe.

This book surveys the scientific achievements and the equipment which made these advances possible, using William Herschel and Ejnar Hertzsprung as two of a relatively small number of astronomers who brought this about.

Two hundred years ago astronomers asked very simple questions by today's standards e.g. "how many stars can be counted?" or "how accurately can we measure stellar positions?" As the twentieth century arrived, questions of greater physical interest were posed, such as "what are the stages of chemical and physical evolution of stars?" By then, it was known that there were widely separated rotating galaxies in an expanding system.

Few scholars have hitherto studied the period considered in this book, unlike the attention given to the earlier Copernican Period. Consequently, there have been no earlier treatments of astronomy over this time at a general level.

Although necessarily brief, for the entire volume summarizes a period of intense activity in relatively few pages, it abounds with interesting information. For example, when Bessel worked through J. Bradley's observation for his *Fundamenta Astronomiae*, he discovered that Bradley has measured the position of Uranus no less than 17 times between 1742 and 1762, though, as one might expect, most of the content of the book relates to astrophysics rather than planetary research as such for it was in this area - in the period covered - that the greatest advances were made.

spaceflight

Correspondence, manuscripts intended for publication and requests for information on membership may be addressed to the Executive Secretary at the Society's Offices at 27/29 South Lambeth Rd., London SW8 1SZ. Tel: 01–735 3160.

NOTICES OF MEETINGS

39th Annual General Meeting

The 39th Annual General Meeting of the Society will be held in the Alliance Hall, Palmer Street (next door to Caxton Hall), London, SW1 on Saturday **22 September 1984**, 3.00 p.m.

Details of the Agenda appear in *Spaceflight*.

35th IAF Congress

The 35th Congress of the International Astronautical Federation will be held in Lausanne, Switzerland on **7–13 October 1984**.

Theme: SPACE BENEFITS FOR ALL NATIONS

Members of the Society wishing to present papers are asked to notify Dr. L.R. Shepherd, Chairman of the BIS International Liaison Committee at Society HQ as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

Lecture

Title: **IRAS: 300 DAYS OF DISCOVERY**
by Dr. John Davies
Leicester University

The Infrared Astronomical Satellite made the first all-sky survey in the infrared, discovering six comets, a dust shell around Vega and star-forming regions in the Galaxy and beyond. Dr. Davies, closely involved with the survey, will describe this exciting mission.

To be held in the Society's Conference Room, 27/29 South Lambeth Rd., London SW8 1SZ on **24 October 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

Space '84

The Space '84 "weekend" will be held in Brighton on **16–18 November 1984**. See inside this issue for details.

Film Show

Theme: **MOMENTS IN HISTORY (PART 1)**

The first of two meetings devoted to historical space films will be held in the Society's Conference Room, 27/29 South Lambeth Rd., London SW8 1SZ on **9 January 1985**, 7.00-8.30 p.m.

The programme will include the following:

(a) The Dream that Wouldn't Down
(b) High Altitude Research
(c) Down to Earth
(d) Vanguard Satellite
(e) Live *via* Early Bird
(f) The Viking Rocket

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Film Show

Theme: **MOMENTS IN HISTORY (PART 2)**

The second of two meetings devoted to historical space films will be held in the Society's Conference Room, 27/29 South Lambeth Rd., London SW8 1SZ on **6 February 1985**, 7.00-8.30 p.m.

The programme will include the following:

(a) A Man's Reach Should Exceed his Grasp
(b) Small Steps, Giant Strides
(c) A Moment in History
(d) Blue Planet
(e) Meteosat

Admission is by ticket only. Members wishing to attend should apply in good time, enclosing a stamped address envelope.

36th IAF Congress

The 36th Congress of the International Astronautical Federation will be held in Stockholm, Sweden on **7-11 October 1985**.

Members of the Society wishing to present papers are asked to notify Dr. L.R. Shepherd, Chairman of the BIS International Liaison Committee at Society HQ as soon as possible. Members wishing to present papers to the IAF Student Conference must submit them through the Society.

LIBRARY

The Library will be open to members from 5.30 to 7 p.m. on the following dates:

26 Sept 1984	24 Oct 1984
14 Nov 1984	5 Dec 1984
9 Jan 1985	6 Feb 1985

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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spaceflight

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SUPERIOR INTELLIGENCE OR INFERIOR ARGUMENT?

The media are renowned for blowing up trivia to matters of colossal importance and to compensate on another occasion by producing a completely negative view under the guise of sincere argument. A surprising new recruit to this approach was the BBC TV Horizon programme on 21 July last, reputedly to honour the first Apollo moonwalk – surprising because earlier programmes of this type have shown such excellent objectivity. It pretended superior intelligence but produced inferior argument.

Adopting the guise of reasoned approach, this programme presented a jaundiced view on the development of space stations almost totally lacking in debate. In fact, John Hodge, as the NASA representative, gave a purely factual account of space station plans – seemingly oblivious of the cut-in remarks of scientists and others bent on shooting down the very concept. It was a complete antithesis of reasoned argument, with the result that the "anti" space station lobby sailed through without a shot being fired in return!

To set the scene, the presenter, James Burke, introduced the remark that space will be either "a Sea of Peace" or "*a new terrifying Theatre of War*", undoubtedly knowing well that the key position of such phraseology was certain to induce bias. Actually, the same argument could probably be advanced to every discovery or invention by man and to every spot on the globe where he has set foot, from the Arctic to the Equator. Put in this context, the bias would disappear and realism emerge. As presented, the programme induced this initial bias and continued with a series of innuendoes:

1. The development of a space station would be money wastefully spent.
2. It was hardly a new stepping stone anyway – i.e. it lacked even the appeal of originality.
3. Space manufacturing appeared to be simply a gimmick.
4. The military do not seem to want it.
5. Its use as a science laboratory was very limited.
6. A space station would have an adverse effect on space science by competing for resources.
7. It is too limited in its scope and everything can be done better by robot equipment.
8. It cannot reach many satellites, particularly those in geostationary orbit.
9. It is a science fiction idea anyway.

Such loose statements about space have arisen before, yet while people change, as does the context of their quibbles, nothing

Continued overpage

COVER

Shuttle Orbiter *Discovery* stands poised ready for its first orbital voyage. A successful launch on 30 August ended weeks of delay and led to the release of three communications satellites. NASA.

has varied fundamentally over the past three decades beyond the fact that some of the comments once made are now seen to be the ill-informed remarks they always were. Quibbling of this sort appears to apply to almost every new area of human endeavour. For example, not long ago a radio programme contained a discussion for and against setting up a new theatre. The arguments were so familiar that, simply by deleting the word "theatre" and inserting the word "space," the whole programme could have been repeated on another theme!

Exactly the same sort of quibbles, *albeit* with slightly different emphasis, were asked about the railways, perhaps even about the wheel and probably everything else back to the harnessing of fire! In every case there were undoubtedly a multitude of authentic reasons why it (whatever *it* was) either could not or should not be done. To take the case of the railways, for example, it was "well-known" that anyone travelling at more than 25 mph would die through heart failure. In the case of space, men could not work there "because the moisture used to lubricate their eyes would be weightless – with the result that the eyes would become too inflamed to enable astronauts to see properly." Add to this perforation by meteors, death through cosmic rays, reduction to a thin smear from acceleration and deceleration – and a final sinking into the quicksand of the Moon on arrival, for those with the temerity to brave all the earlier dangers!

The misrepresentations of the BBC TV Horizon programme cannot be allowed to pass unchallenged;

1. *The space station would be money wastefully spent.*

One can think of many examples which dwarf space expenditure in wastefulness, e.g. foodstuffs over-produced and destroyed though needed elsewhere on our planet: Government expenditure on abortive projects, e.g. right back to the famous "ground nuts scheme" shortly after the war (when we really needed the money!): projects cancelled before achievement: money spent on running failing industries (the so-called "lame ducks"): strata of unnecessary officials with all their perks. In fact, any money syphoned into an area where the return is not commensurate.

Space monies are spent attaining new knowledge, developing new technologies and new management techniques, formulating innovative experiments and grasping the potential offered by the entire Universe – with every promise of a wealth of new data. Every knowledgeable person ought to recognise *that* and accept that *all* knowledge is potentially useful and can be expected to be applied sooner or later.

Were communications satellites *wasted money?* The rockets which launched them certainly were – or so it was said. Now who can imagine a world without communications satellites? The same applies to weather, navigation and a host of other services. The development of computers and miniaturisation, now affecting everyday life, stemmed largely from the stimulus of space activities. In fact, the ripples now extend so far that most users are oblivious of their origins. The essential fact is that space *stimulates* and, thus, leads to endless possibilities.

Additionally, of course, money is not wasted "up there." It is spent *on Earth*, constructing new facilities, new technologies, new factories and developing new areas of education and new skills. The only questions which should be open to debate are:

a. Which particular path of advancement into space is likely to prove the most beneficial.
b. What should be the proportion of its Gross National Product that a country spends on space, bearing in mind the prevailing conditions and increasing opportunities for space developments.

2. *The space station is hardly a new stepping stone*

Nor, indeed, was the rocket, nor even the prehistoric dream of man to fly. It is a tribute to dreamers that so many ideas are thus created: and a tribute to those scientists and engineers who realise them. The criticism that space is "hardly new" is simply a derogatory remark intended to create further bias.' Even if the space station idea is not new, its *achievement* certainly *will be*.

3. *Does space manufacturing have a real basis?*

As with all new advances, applications are not always immediately apparent. The initial usage of a space station was, basically, intended as a stepping stone to the Moon and planets – things which may yet emerge. Manufacturing e.g. of pharmaceuticals in space, is in the nature of a spin-off, *albeit* an important one, which has yet to be evaluated, probably along with many other manufacturing, research and scientific processes.

The truth is that space station facilities have not yet been created and so have yet to be fully examined and exploited. The full potential of a space station cannot be realised until it is actually *there*. Such "What is the use of it?" questions has been repeated over the ages. Faraday's reply, "What is the use of a new-born babe?" was as good as any.

4. *The military does not want it*

Space station development does not depend on a solely military usage, any more than did that of ships, aircraft or cars. *Stimulus* can come from such sources but the space station case does not rest on this alone.

5. *It has a very limited scope*

So does a baby, so did the wheel, so did fire, so did electricity. "Limited Scopes" are typical of early stages of development. It is the *potential* which is important.

6. *Adverse effect on space science by competing for resources*

The same argument could be put by deleting "space science" and inserting National Health coverage, housing, help for the Third World, undersea exploration, larger police force, better railway service – or anything else one cares to think of.

Stripped of its verbage, this is simply an argument for not doing anything about anything at any time – on the ground there will always be something else that will suffer an "adverse effect."

The whole argument collapses with an understanding of economic production and a realisation of how resources are created.

It is new inventions, new discoveries, new techniques and new skills which *create* resources. This argument attempts to foreclose on progress by ensuring that nothing will ever be done, on the grounds that e.g. a better drainage system is needed in Littlehampton.

7. *Everything can be done better by robot equipment*

The robot indicated in the Horizon programme was the Space Telescope, though it is those who *advocated* space progress over the years who should be credited with the Space Telescope, for they created the conditions to make it possible. Had arguments similar to those now advanced

Concluded on p. 432

STARTING POINT FOR SPACE

By Curtis Peebles

NASA operates a whole series of space centres spread across the United States. This issue begins an occasional series in which Curtis Peebles takes a brief look at the main establishments, their history, their present activities and what work they will be performing in the future.

Introduction

The first human inhabitants of what is now the Kennedy Space Center migrated into the area about 10,000 years ago. Europeans arrived on the scene in 1513, with the Ponce de Leon naming the area Cabo de Canaveral (Cape Canaveral). For the next three centuries the Cape remained solely as a navigational landmark.

In the early 19th century, oranges were being exported from the site and in the 1880's the towns of Cocoa and Titusville were established. Still the Cape remained a backwater - small towns, a few hunters and tourists. Then, in the late 1940s, all that changed; the swampy scrub land began to become the gateway to other worlds.

Joint Long Range Proving Ground

It was apparent at the end of World War II that long range rockets would play an important role in future conflicts. Such weapons would need to be tested and this posed a problem - even the largest US test range, White Sands in New Mexico, was too small. The limited V2 could be tested to only half its potential range. Accordingly, on 9 July 1946, a joint government and civilian panel was formed to look for a suitable area. The importance of their task was underlined on 29 May 1947 when a wayward V2 launched from White Sands crossed the border and impacted near Ciudad Juarez, Mexico.

Less than a month later, the committee had completed its recommendations. There were three possibilities, all based on the need for a string of tracking stations along the missiles' projected flight paths. A launch site in Washington State, with tracking stations located on the Aleutian Islands, was examined but relegated to third place because of the appalling winter weather. The committee's first choice was the El Centro Naval Air station in California. The rockets would be fired to the south, down the Gulf of Mexico and into the South Pacific, with tracking stations on either side of the Gulf. Unfortunately, the President of Mexico was less than enthusiastic (possibly because of the V2 incident) and refused permission for the tracking stations. In December 1947, the committee's second choice was selected: Cape Canaveral in Florida [1].

The Cape

Cape Canaveral had several advantages and most of the land was undeveloped and thus easy to acquire. Some 29 km to the south was the Banana River Naval Air Station, a former World War II sea 'plane base, now closed, that would serve as the administrative headquarters. The major advantage was that the Cape faced the open Atlantic Ocean - wayward rockets would not be a problem and tracking stations could be established on islands stretching downrange from Grand Bahama to Ascension Island. Negotiations began in March 1948

A Shuttle begins the 5 km journey from the Vehicle Assembly Building to pad 39A, lost in the distance. Pad 39B, off to left, is being prepared for Shuttle operations. *NASA*

with the British and Bahamanian governments and were completed in principle in February 1949. On 1 October 1949, the Joint Long Range Proving Ground was officially established and preparations began for the Cape's first launch. It was to be a V2 with a WAC-Corporal upper stage launched vertically, then pitched over on to the horizontal - something that had not been done before.

Compared to what would follow, that first launch was primitive. The gantry, for instance, was a pipe-work monstrosity moved by engineers pushing it; only the pad area was concrete and vehicles parked elsewhere sank into the sand. The launch crews' greatest enemies were the hordes of mosquitoes from the surrounding swamps. Despite all this, at 9:28, 24 July 1950, the first rocket fired from the Cape roared into the Florida sky. A few minutes later, it splashed into the Atlantic, its flight a success [2].

The early years of the Cape were taken up primarily with the testing of winged missiles, including both unmanned bombers like the Matador and Snark and anti-aircraft missiles like the Bomarc.

The Redstone missile did not make its first flight until 20 August 1953. At this time, ballistic missiles were not seen as being cost effective but advances in rocket and weapon technology in the mid-1950's made long range missiles practical. The skyline of the Cape began to change. Springing up from the flat, brush covered landscape were the gantries for the Thor, Jupiter, Atlas and

Titan ballistic missiles. The pads were in two areas - the IRBMs (Intermediate Range Ballistic Missiles) in the south end of the Cape and the ICBMs (International Ballistic Missiles) at the northern end. This formed the layout of the ICBM row that is now so familiar [3].

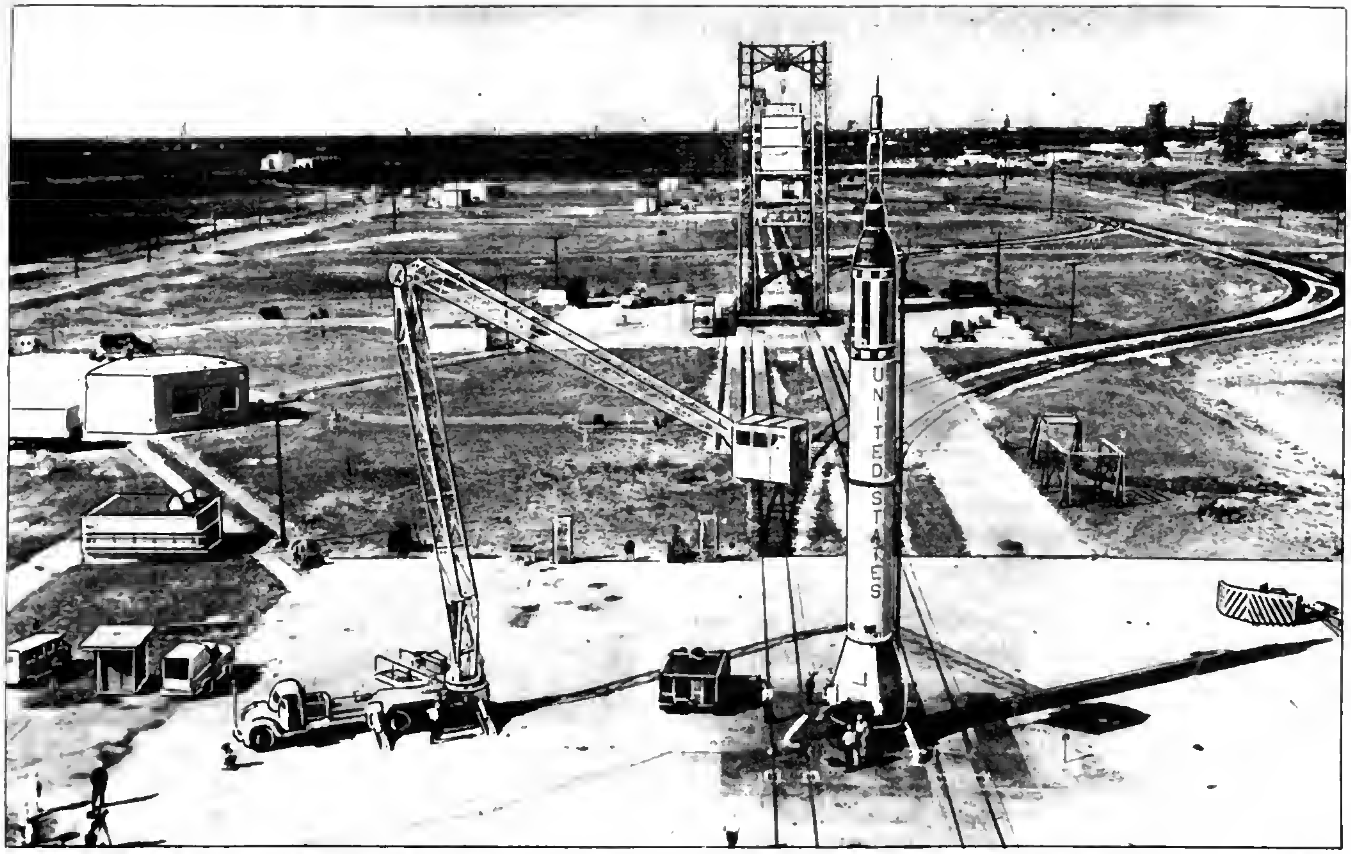
The missile test programmes coincided with the opening of the space age - the same rockets, designed to hit a target thousands of kilometres away with nuclear warheads, could also send satellites and men into orbit. North of ICBM row, pads were built for the Saturn I and IB boosters, the first rockets designed from the start as space launchers. The Saturn pads, however, illustrated a problem: the various launch complexes were crowded into an area only 16 km long. Less than 1 km separated some of the pads - the Cape was saturated. The expanding NASA and US Air Force programmes needed room the old test range could not provide. Various options were studied, including off shore pads on artificial islands or steel platforms, filling in part of the Banana River or moving to Cumberland Island off the coast of Georgia. Finally, a joint USAF/NASA committee settled on Merritt Island, which adjoins the north end of the Cape. The land was purchased in 1961-64; 340 km^2 of land and 225 km^2 of water to allow both room for the pads and a generous safety area [4]. Two pad complexes were built, one for the Air Force's Titan III and the other for the Saturn 5. After President Kennedy was assassinated in 1963 the facility was renamed the John F. Kennedy Space Center. The whole area was renamed Cape Kennedy (this move was not popular with local residents; the name was changed back in 1974).

The Cape Today

Today, many of the old pads are abandoned, left to decay in the Florida sunshine. In the late 1970's, it was felt that the Shuttle would take over all launch activities but, with the various proposals for commercial booster services, it appears that there will continue to be expendable launches for the foreseeable future. There are four active pad complexes. From south to north, the first is Complex 17 (the two Delta pads) A and B, that played host to the original Thor IRBM as well as the various versions of the Delta. Farther north are the two Atlas Centaur pads at Complex 36 mainly used now for communications satellites. They have also seen Surveyor, Mariner and Orbiting Astronomical Observatories. This is the only Atlas pad still active: Complexes 11, 12, 13 and 14 have all been shut down with the retirement of the Atlas Agena booster.

Farther up the coast is the Titan III complex, pads 40 and 41. This facility pioneered the mobile launch concept with the rockets assembled in the Vertical Integration Building. The boosters are then transferred by rail to one of the two pads. Pad 41 was used for the Titan IIIE

The launch of Apollo 11 brought thousands of VIPs and newsmen to the Cape. Complex 39 is now used for Shuttles. *NASA*



Alan Shepard's Mercury Redstone is prepared for launch from pad 5/6 in May 1961. Note the other towers in the background. *NASA*

Centaur which launched the Helios, Viking and Voyager spacecraft, the pads now launch early warning and military communications satellites. It is also used by the Titan 34D, the latest in the Titan family. Pads 15, 16, 19 and 20, used by Titan I and II, are all closed.

The final active complex contains Pads 39A and B. In 1976, after the Apollo-Soyuz flight, work began on modifying the pads and the Apollo support equipment to handle the Shuttle. Only Pad 39A has been outfitted at present but 39B will be ready in 1986. The service structure was completely rebuilt and a 4.5 km long, 91 m wide runway added and an Orbiter Processing Facility constructed. One advantage of the mobile launch concept is the ability to sustain a high launch rate. This was not needed for Apollo but will be useful for the Shuttle, particularly when Space Station launches begin in the early 1990's.

The Cape is not just a network of pads, however. Supporting them is the industrial area 8 km south of the VAB, which includes the KSC headquarters. The largest building here is the Operations and Checkout Building which contains offices, astronaut quarters and spacecraft assembly areas. It was originally built for checkout of Apollo spacecraft but now it is used for preparing Shuttle cargoes and the Spacelab modules. Components of a permanent Space Station could also be readied here. Another important part is the Central Instrumentation Facility, which monitors all the data flowing in from a rocket during ground tests, launch and flight. The industrial area also includes such mundane services as a fire station, warehouses, security offices and parking spaces [5].

Cape Wildlife

Walking a few hundred metres from a pad area, one finds not the high tech of NASA but rather primeval Florida - the way it was before the coming of man. Despite more than three decades of launch activity, most of the Cape is still wilderness. The entire Cape area is part of the Merritt Island National Wildlife Refuge, preserved originally, in the face of the increasing urbanisation of Florida, because of the need for a large buffer area for the Saturn 5. Several species, under pressure elsewhere, thrive. The Cape's alligator population is over 5,000 (some are over 3 m long) and launch crews have been known to feed the "gators" in ponds around the pad areas. Marshmallows are their favourite, although feeding is now against Florida law - alligators do sometimes bite the hand that feeds. Other species living in and around the pads include wild pigs, deer, bobcats, raccoons, rattlesnakes, coral snakes and water moccassins.

The waters of the Banana River are home to about 20% of the manatees in Florida. To protect them, slow speed zones have been established for motor boats to prevent injury or death from propellers. The *UTC Liberty* and *Freedom*, the ships used to tow the Shuttle's solid rocket boosters after recovery, are equipped with water jet propulsion for safety. The Cape beaches are the breeding grounds of several endangered species of giant sea turtles and the skies are filled with birds - some 280 species, including brown pelicans doves, ducks, quail, Canadian geese, Peregrine falcons and the bald eagle [6].

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SPACE '84

16-18 November 1984

SPACE — THE FUTURE OF MANKIND

Our programme for Space '84 at the Brighton Centre introduces a wide variety of space experts covering a wide range of space subjects.

The meeting will be divided into sessions on: New Frontiers, Discovering the Universe, Foothold in Space, Energy and Resources, Advancing Frontiers, the Future of Mankind and Workshop.

The preliminary programme is as follows:

Dr. G. E. Mueller	:	Space: The Future of Mankind
Dr. A. R. Martin	:	Space Resources and the Limits to Growth
Prof. M. Rees	:	Space Astronomy
Dr. J. K. Davies	:	New Eyes in Space
Dr. W. I. McLaughlin	:	The Philosophy of Extra-terrestrial Intelligence
R. W. Easter	:	Space Platforms and Autonomy
I. Bekey	:	Space Tethers
J. L. Blonstein	:	Steps to Space
Dr. D. J. Shapland	:	Spacelab – A Laboratory for the Future
Dr. J. T. Houghton	:	Remote Sensing of the Oceans
C. Honvault	:	Operational Meteosat
J. Casani	:	Project Galileo
R. P. Laeser	:	Voyager: Now Through Neptune
K. Gallagher	:	Time and the Space Ships
R. M. Jenkins, D. C. R. Link and J. Simpson	:	Giotto Update
Dr. G. Haskell	:	Asteroid Probe
G. P. Whitcomb	:	Future Missions for the ESA Science Programme
S/L R. M. Harding	:	Space: Human Physical and Mental Adaptability
Dr. R. C. Parkinson	:	The Prospects for Colonising Space
A. T. Lawton and Penny Wright	:	Monopoly: A Monopole Motor for Interstellar Propulsion
R. Gibson	:	European Involvement in Space Station Development
R. J. H. Barnes	:	European Space Autonomy & Cooperation with NASA: An American View
Dr. H. Joyce	:	Space Radar Systems

Ladies Programme

Two special Ladies Programme excursions have been arranged for Space '84. On Saturday, 17 November, there will be a private tour, with coffee, of the historic Royal Pavilion in Brighton itself, Sunday, 18 November, will see an all-day tour by luxury coach through the Sussex countryside, including a visit to the House of Pipes (for coffee) and lunch at Barnsgate Manor Vineyard, tour of the vineyard, wine-tasting, etc.

Further details on both events are available from the Executive Secretary. Early booking is essential.

Civic Reception and Banquet

A Civic Reception (dance/supper) by courtesy of the Brighton Corporation will be held in the Brighton Centre on the Friday evening to give everyone an opportunity to meet before the conference proper begins.

Highlighting Saturday's social activities will be a Banquet with Guest Speakers Sir Peter Masefield, Ted Mallet and Patrick Moore. The aperitif, 4-course meal and half bottle of wine per person will be provided at a cost of £18.00 per ticket.

To keep the friendly atmosphere of Space '82, the number of places available will be held down to 400. Simply fill out the form below and send it to the Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London, SW8 1SZ.

SPACE '84 SOUVENIRS

Special Space '84 souvenirs will take the form of beautiful crystal glass mugs and decanters, donated to the Society by Western Glass International to support our fund-raising ventures. All are embossed with the Society's motif and some, additionally, with the Space '84 logo, too, for those who want this also.

Several types are available: pint sized-tankards at £10, and half-pint tankards at £6: Special silver-handled half-pint tankards at £7.50 and decanters at £25.

Please forward a registration form and details on Space '84. I enclose a 20p stamp.

Name: . . . .

Address: . . . .

. . . .

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Trail-Blazers or Ballast?

Sir, Inadequate thought is given to the longer-term implications of space travel and how these should be provided for, such as the institutions required and how spin-off will affect mankind at many other levels e.g. social, legal, education, moral and political.

Lacking a crystal ball, we cannot anticipate any untoward factors that may alter the picture drastically, though we will certainly get a cuff on the ear from posterity if our ideas are wrong. When we extrapolate into the future, even if gingerly and with a certain degree of inbuilt flexibility, the main implications seem to lie in:

1. Sources of energy and materials.
2. Unexpected discoveries of a completely new character.
3. New attitudes of mind and adoption of new techniques.
4. Development of organisation and management abilities.
5. Ethical and moral development.

In my view the major unknown in this is item 5, i.e. man himself. Mentally, he is not a homogenous creature. Some will always be trail-blazers but the great majority, particularly those who can't keep up with things, are more likely to prove to be in the nature of ballast. If the race becomes prolonged, will not the abilities of the humans in it become spread out even more than they are at present, with those in the lead feeling "the loneliness of the long-distance runner" even more than hitherto?

Some have already posed the question "Are we ready to let mankind loose into space?" If we do, we ought to restrict it to those of advanced intellect but it is certain to include many motivated by attitudes, standards and aims that are less then desirable, if not distinctly odious. Few humans, on a moral level, may be worthy of the task, even if many think they are.

If we are to make moral progress we will need to envisage some completely new, and probably unattainable, yardstick and endeavour to work towards it.

It is better to aim for a star and fail, rather than to aim for the nearest sewage farm and score a bullseye.

P.R. FRESHWATER
Henley-on-Thames, Oxon

Shuttle APUs

Sir, Your item "STS-9 in Retrospect" on p.160 of the April issue, which mentions the post-landing "fire and explosion" of the Auxiliary Power Units (APUs) caught my attention. Myself and another engineering representative of the APU manufacturer were the first "APU system engineers" on the scene hours after Orbiter landing. Our objective was to make an inspection of the APU units to confirm our suspicions of significant damage which was evident in our analysis of APU parameters "real-time" during entry and shortly after post-landing.

It was surprising to read that a NASA spokesman did not know of the fire although he was at the landing site. Our report on the extent of the observed damage was transmitted simultaneously to the Johnson Space Center and Kennedy Space Center as well as to Rockwell management and to the APU suppliers' facility on the night of the second day. It may have been that NASA wished for time to assimilate the facts so that a cogent report could be issued to the press on the incident.

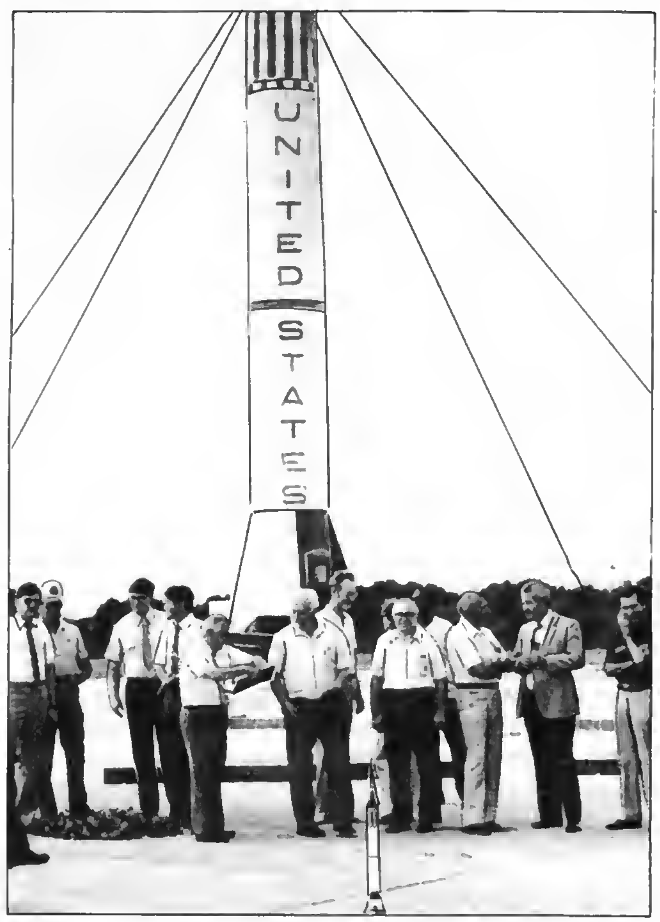
STANLEY M. BARAUSKAS
California, USA

Unmanned Shuttle

Sir, It has been stated that the Space Shuttle requires direct astronaut interaction and cannot be launched on an unmanned test flight. The orbiter is equipped with five of the most sophisticated computer systems ever flown. I thought that the more computerised a vehicle was, the easier it would be to fly it by onboard computer control only, or by that plus remote interaction from ground control. Yet apparently not in the case of the Shuttle, while the relatively primitive Soyuz and its derivatives are regularly launched unmanned.

STEPHEN ASHWORTH
Oxford

Capt. John London tells us that an informal group of US Air Force officers marked the 23rd anniversary of Alan Shepard's sub-orbital Mercury flight on 3 May 1961 with the flight of a scale model Redstone from Complex 5/6 at the Cape. Members of the original 1961 team attending included Karl Sendler (part of the von Braun rocket team), who was presented with the model after its 150 m flight. Capt. Jim Tippins wired the model to be fired electrically by Sendler from the same blockhouse launch panel used for Shepard. It is hoped that a more substantial ceremony can be arranged for the 25th anniversary in 1986.



Astronaut Ron McNair.

STS-11 Puzzle

Sir, Why did the photograph of the STS-11 crew in the January 1984 issue (p.12) show Ron McNair with an STS-3 mission badge on his overalls? As far as I know, he wasn't a back-up, or am I wrong?

Was he connected with STS-3 in relation to an experiment carried on-board *Columbia* during that mission?

G. SIMMONDS
Worcester

Astronaut Ron McNair answers:

"Very interesting observation by your reader. I was on the STS-3 T-38 chase team and the STS-3 patch was a part of our attire. At the time of this photo, the 41B patches were not yet ready - so why modify my old flight suit? That's the story!"

Half-Way There?

Sir, Certainly my BIS certificate looks impressive – and I love it! However, the alteration of 'his' to 'her' (I took script writing at Art School) prompts me to ask exactly how many other lady members there are?

It has always worried me that we seem to want to send only half a race to outer space: I only hope that the fathers and brothers in the BIS are busy educating their wives, sisters and sweethearts. It will all be an empty gesture otherwise.

MARY SUTHERLAND
Kappela, Austria.

US Navy Satellite

Sir, Earlier this year the US Navy announced that it had launched a 59 kg subsatellite very cheaply by basing it on plume-shield hardware that is normally discarded after launch. The satellite, called LIPS (for Living Plume Shield), carried an experimental transponder and a test panel of gallium arsenide solar cells. It was powered by three solar panels and used a gravity-gradient stabilisation system. The plume shield, which protected the primary payload from the final stage rocket plume during launch, was a disc-shaped object 1.8 m in diameter and 0.1 m high.

No information on the launch date or launch vehicle was given but a probable identification can be made using the following facts.

Launches of the US Navy 'Whitecloud' ocean surveillance project normally deploy three surveillance subsatellites into closely related orbits from a manoeuvring mother satellite. After launch, a single piece of debris is initially tracked in orbit with the mother satellite and the subsatellites (accompanied by more debris) appear several days later. On the fifth Whitecloud launch an extra subsatellite (1983-08B), using slightly different transmitting frequencies to the three standard sets, appeared instead of the normal initial piece of debris.

It seems highly probable that the usual piece of debris is a plume shield and that 1983-08B is the LIPS satellite.

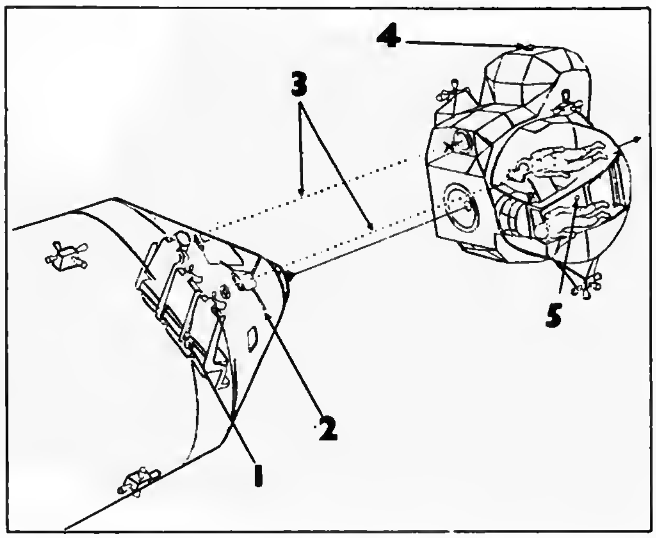
G. R. RICHARDS
Sutton, Surrey.

The Editor is always interested in receiving items of correspondence, notes, comments, or reviews for possible publication. Items submitted must be kept brief, owing to the limitations of space in our magazine. The Editor reserves the right to shorten or otherwise adapt material to fit, for this reason.

Apollo 9 Docking

Sir, After reading of the 90° docking mystery of Apollo 9 (letter by Phillip Clark, *Spaceflight*, p. 345), I have come to the conclusion that there never was a 0° docking angle during any Apollo mission (except ASTP). During docking the CM pilot (sitting in the left hand seat) had to align the CM's Y-axis with the long beam of the LM's reticule. (The + Z axis was aligned with the short beam.) A picture of the Apollo 14 LM *Antares* indicates that an alignment of the LM and CM hatches during the docking was just impossible!

LORENZ HURNI
Switzerland



1 and 4: docking lights; 2:orientation scale; 3: mutual sightline; 4: position light (for long distance).

Apollo 9: From the Horse's Mouth

Sir, The day that your September/October issue of *Spaceflight* was delivered, I was with astronaut David Scott, the Apollo 9 commander, and I drew his attention to the letter on p. 345. Although the Command Module and Lunar Module are not docked at a 90° angle as stated, confusion may have arisen because the earlier versions of the Lunar Module did feature two docking ports. It was found in simulations that although crews could learn to dock on either port it was an unnecessary strain to have to sight up visually by looking up at a window above their heads. The idea of two docking ports was dropped after Apollo 9.

FRANK MILES
Head of ITN Science

MILESTONES

July 1984

16 The US NOAA 8 weather satellite is now tumbling because of master time controller failure. Saving the $30M satellite is unlikely.

17 George Low, a key Apollo manager, dies of cancer at the age of 58. His son has recently been selected as a NASA astronaut.

18 Soyuz T-12 is launched with Vladimir Dzhanibekov, Svetlana Savitskaya and Igor Volk to Salyut 7. It docks at 23.17 Moscow Time. Savitskaya makes an EVA on 25th and becomes the first woman to fly twice in space. T-12 lands 140 km E of Dzhezhazgan on 29th at 16.55 MT.

25 Svetlana Savitskaya makes first EVA by a woman, in 3 h 35 m walk with Dzhanibehov outside Salyut 7. Kathryn Sullivan will make Shuttle EVA in October.

29 The US GOES 5 meteorological satellite fails in orbit, the GOES 7 replacement is not due until May 1986.

30 The Space Development Council of Japan has approved the development of the H2 launcher to handle 1500 kg in geostationary orbit. The first two stages will be cryogenic.

31 The International Solar Polar Mission, due to be launched in May 1986, is renamed 'Ulysses.'

August 1984

1 The Japanese launch their US-built GMS 3 meteorological satellite with an N2 rocket to replace the failed GMS 2 in geostationary orbit. ESA has offered to sell a Meteosat and Ariane launch to Japan for $60 million.

4 The first Ariane 3 successfully launches the ECS 2 and Telecom 1A communications satellites from South America.

7 The Spacelab 3 experiments successfully complete a week of integrated tests at KSC. They will be installed in December and launched next January.

8 Salyut 7 cosmonauts Kizim and Solovyov make an 8 hr EVA to continue repairs on the station's main engine.

16 Progress 23 docks with Salyut 7, following launch on 14th, to bring fresh supplies.

16 The triple AMPTE satellite payload is launched by Delta 3924 to study the magnetosphere.

20 NASA's Johnson Space Center issues the preliminary Request for Proposals for the Space Station. Studies will concentrate on the 'power tower' design.

30 Shuttle *Discovery* is launched on its first flight. Mission 41D releases the Syncom 4-2, SBS and Telstar 3C communications satellites.

Please note that some of the dates quoted above refer to the "announcements" of the events and not necessarily to the events

DO YOU KNOW?

This rather strange photograph shows, in fact, a piece of space history. The only clue is that the display is in the US National Air and Space Museum in Washington, D.C.

Answer: 'Uncle Sam' is holding the Vanguard satellite from the ill-fated orbital launch attempt of 6 December 1957, publicised as the US response to Sputnik. The rocket exploded and the still-bleeping satellite was thrown clear. The failure meant that Explorer came forward as the first US satellite, leaving the next Vanguard attempt to bring up the rear in March 1958. Our thanks to Joel Powell for the photograph.

DO YOU REMEMBER?

25 Years Ago...
2 November 1959. It is decided at a NASA meeting that a post-Mercury spacecraft should be able to carry a three-man crew on a circumlunar flight, be adaptable for operations in Earth orbit and be used as a crew cabin for more advanced lunar landing spacecraft.

20 Years Ago...
18 October 1964. The Gemini 2 spacecraft reaches launch complex 19 at Cape Canaveral. Launch of this final unmanned Gemini mission took place in January 1965.

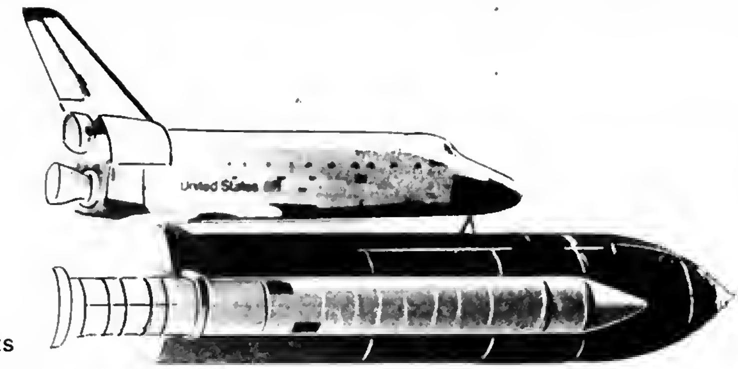
15 Years Ago...
14 November 1969. Apollo 12, the second manned lunar landing mission is launched with Conrad, Gordon and Bean aboard. The rocket is hit by lightning 1.8 km above the pad but the flight proceeds safely.

10 Years Ago...
6 November 1974. The Soviet unmanned Luna 23 lands on the Moon. This soil-sample return attempt fails due to drill damage soon after landing.

5 Years Ago...
30 October 1979. The 181 kg scientific satellite Magsat is launched by Scout rocket from Vandenberg Air Force Base in California to measure Earth's near-surface magnetic fields.

SPACE REPORT

A monthly review of space news and events



SPACE SHUTTLE

UK ASTRONAUTS IN TRAINING

Early in 1984 the UK Government revealed that it had selected four UK Payload Specialist candidates for astronaut training with a view to one flying on a 1985 Shuttle mission with a Skynet 4A military communications satellite. A second man, after serving as backup on the first mission, will fly in 1986 with Skynet 4B. The two men will be chosen next summer, writes Dave Shayler.

In December 1983 the Government decided to use the Shuttle to launch the satellites rather than ESA's Ariane. The Skynet communications satellite series has been the main UK military satellite communications system since the late 1960's, used by all three major military services. Built by British Aerospace, each Skynet 4 has a design lifetime of seven years and weighs 6,260 kg at launch.

Once the Shuttle had been chosen, NASA's offer of allowing one UK citizen to fly with each satellite was accepted. Since the satellites are military, the candidates were limited to serving military personnel or Ministry of Defence employees. Selection criteria included: an appropriate degree; a full understanding of the satellite systems; a mature and stable personality and "the capability of working as a team member in close confines under the unique stress of space flight." All had to be physically fit and perform well under stress. Previous flying experience was not necessary, however, as they would not be called upon to operate the Shuttle flight controls. All applicants had already been screened for security as members of the military service, the MoD and Skynet project team.

Top left: Nigel Wood (RAF), *top right:* Richard Farrimond (Army); *bottom left:* Peter Longhurst (RN); *bottom right:* Chris Holmes (MoD).

Training within the UK will be with the Skynet Project team and at the primarmy contractors British Aerospace, Stevenage, and Marconi Space and Defence Systems [MSDS], Portsmouth. Training in the US will be mainly at the Johnson Space Center in Houston and at the Kennedy Space Center in Florida.

Once the two prime candidates have been chosen, they will join the NASA flight crews to train for the specific missions using NASA simulators for some three months.

In March 1984 four names had been identified as Payload Specialist candidates, all members of the Skynet team and well-aquainted with the satellite. Three of the four were serving military officers, one each from the Army (Royal Signals Lt. Col Tony Boyle); Navy (Commander Peter Longhurst) and Royal Air Force (Sqn Leader Nigel Wood). The fourth was a civilian employee of the MoD Procurement Executive (Mr. Christopher Holmes).

On 14 June it was reported that Lt. Col Boyle was being replaced by the Army's second choice, Major Richard Farrimond, because Boyle was needed back in the UK for work on an important security case.

Major Farrimond of the Royal Signals possesses a degree in telecommunications engineering while Chris Holmes (MoD) was Skynet 4 Deputy Project Manager from last year until his selection. Cdr. Peter Longhurst has worked on Skynet since 1981 and Nigel Wood of the RAF, while not previously involved with the project, is an experienced test pilot.

SPACELAB MISSIONS

The highly successful flight of the European Space laboratory Spacelab aboard the Space Shuttle last December paved the way for a whole series of missions in the future. The next, Spacelab 3, will fly in January with experiments on materials and animals that take advantage of the long periods of weightlessness in orbit. Spacelab 2 will fly *after* number 3, in April 1985, because its astronomical experiements to observe the Sun were not ready in time to fly first. Both of these missions might slip a few months because of the delays carried by the aborted Shuttle 41D launch attempt in June.

In October 1985, the Germans will sponsor the Spacelab D1 mission for further material and life sciences experi-

ments. The next month should see Earth Observation Mission 1 aboard Shuttle *Atlantis*, a flight added when the late launch of Spacelab 1 cut short some of the experiments.

Spacelab 4 in January 1986 is wholly devoted to studying animals, including many in weightlessness, and Spacelab 8 in May 1987 will be the first flight of the "International Microgravity Laboratory." The numbers do not follow order because so many changes have been made to the schedules.

January 1988 should see Spacelab J, a whole mission dedicated to Japanese experiments in microgravity. These, like those of SL-8, will study the behaviour of liquids and materials in zero-g.

UK SPACELAB 2 TELESCOPES

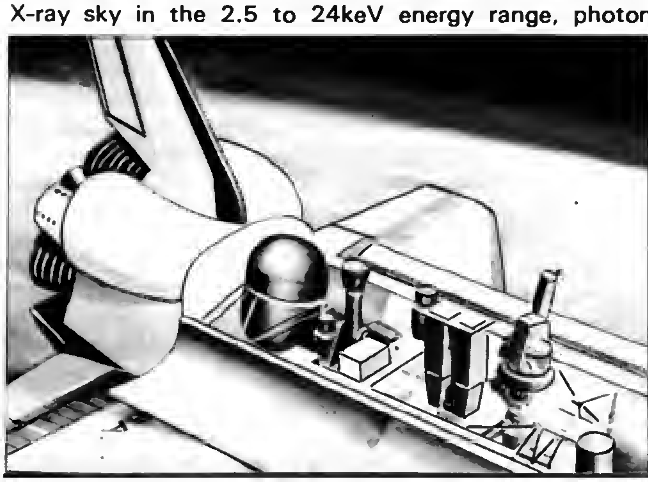
Two UK scientific instruments are now being integrated into the Spacelab 2 payload for flight on the Shuttle next April: 'Chase' (Coronal Helium Abundance Spacelab Experiment) and the 'Coded Mask Telescope.'

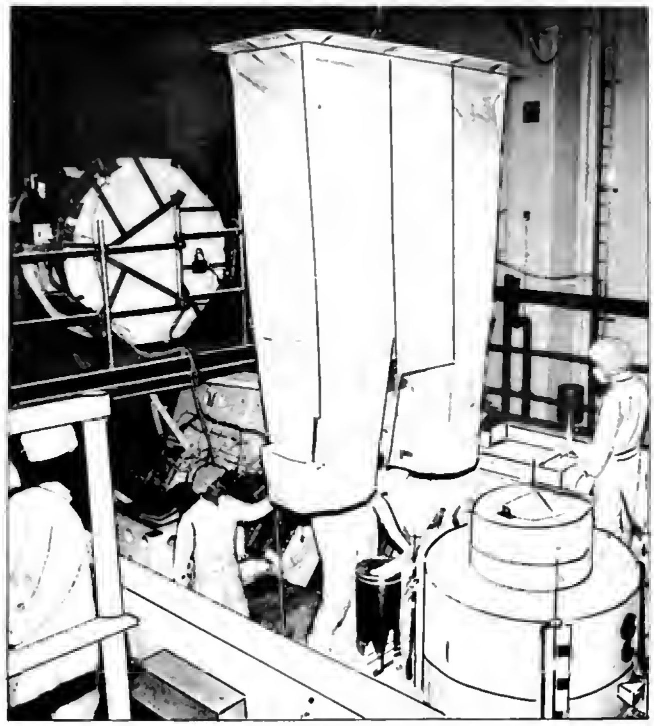
After hydrogen, helium is the most abundant element in the Universe, with about 10% of the number of atoms. In spite of this, its actual abundance is poorly known; existing measurements lie between 5 and 25%. It is hoped that Chase, by using a new technique, will determine this abundance in the solar corona to an accuracy of one-tenth. There are good reasons to believe that this coronal abundance is typical of the Universe in general because it will have been increased only marginally by nucleosynthesis in stellar interiors. Thus, the measurement will be directly related to the primaeval helium abundance, the concentration produced in the Big Bang at the beginning of the Universe.

Chase consists of a 2 m grazing incidence spectrometer covering the 140-2350Å wavelength range, illuminated by a two-reflection grazing incidence telescope, and will observe the hydrogen 1216Å and ionised helium 304Å emissions.

The second UK instrument is the Coded Mask Telescope, which consists of two telescopes mounted side by side on a pointing mount. It will be given instructions once per orbit, either by the Spacelab payload specialists or from the payload crew in the mission control centre, and will then operate almost autonomously until those commands are updated. Since the telescope is so large, it is essential that its operation should present no hazards to the Shuttle. Accordingly, one control system operates the telescope while a second monitors its performance, ready to take over if it detects evidence of a malfunction.

A major target will be the central region of the Milky Way, where it will obtain high resolution images of the X-ray sky in the 2.5 to 24keV energy range, photon





Technicians install the UK Spacelab 2 'Coded Mask Telescope.' *NASA*

energies not accessible to current X-ray optical systems. The Galactic Centre, which is heavily obscured by large photoelectric absorption at lower photon energies, can also be examined. The 'coded mask' technique uses an opaque sheet with a pattern of holes to cast a 'shadowgram' of the scene on to a position-sensitive detector. The shadowgram will be relayed to the ground and transformed by computer analysis into an image.

A week-long series of tests designed to verify the compatibility of the Spacelab 2 experiments with each other and their simulated Spacelab support systems was successfully completed at the Kennedy Space Center on 20 July. The Mission Sequence Testing marked the first simulation of mission operations using the actual flight experiments, according to Spacelab 2 Mission Manager Roy Lester of Marshall's Spacelab Payload Project Office. "We operated all of the instruments simultaneously, just as they will be operated on orbit during the mission next April," Lester explained. "Both the flight and alternate payload specialists and two of the three mission specialists participated in the testing.

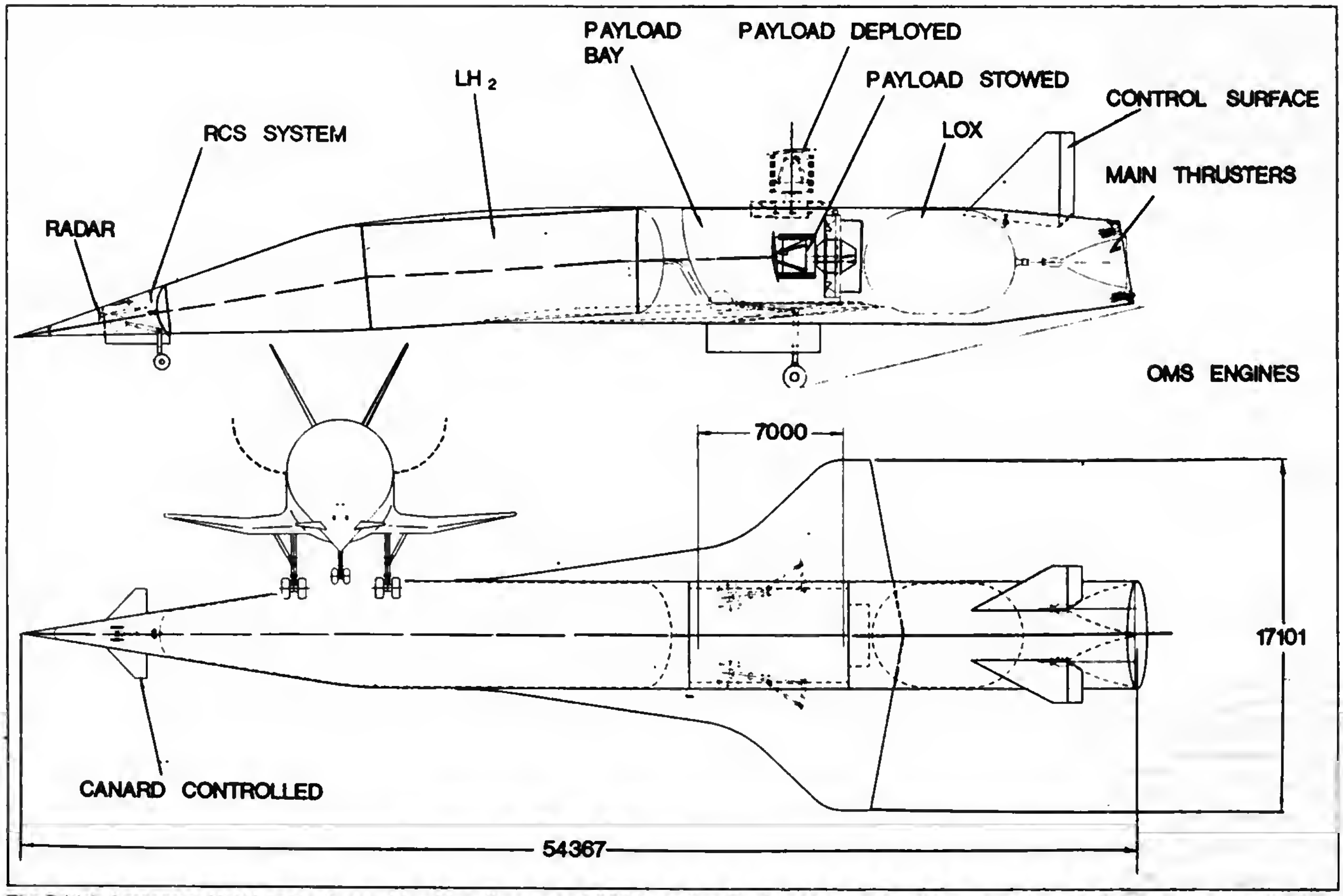
The testing brought the Spacelab 2 'Level IV integration activities' to a close. These included installation of the experiments on to the U-shaped support pallets, connection of the wiring and plumbing, and the initial power up and checkout of the instruments.

Spacelab 2 will consist of 13 experiments in solar physics, atmospheric physics, infrared astronomy, high energy physics, life sciences and technology, most of them carried on three Spacelab pallets in the Shuttle cargo bay.

BAe SHUTTLE STUDIES

British Aerospace is studying a new concept for launching payloads of up to 7000 kg into low Earth orbit. 'Hotol' (Horizontal Take-off and Landing) is an aircraft-type vehicle, using standard runways of Concorde length. It would reach low orbit using a combination of air breathing and rocket engines.

The key features of the US Shuttle are its reliability



The British Aerospace Hotol concept, capable of handling up to 7000 kg to low Earth orbit in its 9 x 4.5 m cargo bay. Rolls-Royce are contributing to the propulsion studies. (Dimensions in mm.)

and re-usability. However, the Orbiter design has been compromised by a need to turn it into a miniature Space Station that can remain in orbit for lengthy periods; it needs a throw-away fuel tank plus boosters to augment the thrust of its own engines.

Ideally, a re-usable launcher should have no expendable parts and should be capable of repeated operations with a minimum turnaround, with minimum interfaces with its cargo. It should accommodate a typical single satellite of 4 to 7 tonnes (or a pair of this total) to low orbit and need not be manned. Automatic and remote piloting control systems are already capable of handling ascent, in-orbit manoeuvring, payload deployment, and re-entry.

A vertical take-off version will always suffer from the unfortunate fact that the Earth's gravitational field is about 10% too high to make a single-stage-to-orbit rocket practical, even with the highest performance propellants of the foreseeable future. This means that vertical take-off will always need a two-stage lift; many proposals exist for such systems, including fly-back boosters.

In a liquid hydrogen/liquid oxygen rocket (the highest performance available today), 85% of the propellant mass is oxygen, which has to be lifted by the launcher to feed its engines. But the launcher is flying through a sea of free oxygen and if air-breathing propulsion could be combined with rocket propulsion in the early phase of flight to gain that 10% advantage, a single-stage-to-orbit could be achieved. Vertical take-off would not be necessary. There is a trade-off between the mass of combined propulsion systems and the mass of wings to give lift, and the trade-off favours wings. It would then become feasible to design a launcher in which there is no payload mass penalty to be paid for the lower thrust/mass performance of combined air breathing and rocket propulsion. All that is needed is extra concrete to extend the length of the runway.

FIRE IN SPACE

During a Shuttle mission in 1986, writes Joel Powell, a fire will be started on board the Orbiter - a controlled fire inside an experimental chamber to study the ignition and propagation properties in microgravity. Ever since the tragic Apollo fire in January 1967, NASA has feared a fire in an orbiting spacecraft and Professor Robert Altenkirch of the University of Kentucky has devised an experiment using plexiglass and filter paper to learn more about fire in space. The experiment will have applications in the design of detection and fire protection systems in the Space Station.

GRUMMAN SHUTTLE EXPERIMENTS

The Grumman Corporation plans to fly three simple experiments aboard the Shuttle in the near future to gather baseline data on several materials that can be produced in space, writes Joel Powell. The first experiment on mission 41D in August involved a furnace to melt bismuth and bismuth-manganese to determine if turbulence and convection during the melt affected or improved the resistance to de-magnetisation of the two ferrous substances. The second experiment in February 1985 will re-test the materials and the third operation, later in 1985, will evaluate samarium and cobalt for added resistance to de-magnetisation.

SHUTTLE SCHEDULE AND CREWS

Several Shuttle crews have been shuffled around in a series of changes announced by NASA. Veteran astronaut Henry Hartsfield, commander of 41D, will command flight

61A, the German Spacelab mission planned for launch on 14 October 1985. James Buchli will be a mission specialist. Pilot Steven Nagel, mission specialists Guion Bluford and Bonnie Dunbar, and payload specialists Reinhard Furrer (German), Ernst Messerschmid (German) and Wubbo Ockels (Dutch) had already been selected.

The crew for 41F, commanded by Karol Bobko, has been reassigned to 51E, scheduled for 12 February 1985. The original flight was deleted and some of its cargo placed on 41D after the launch abort of late June.

The list below was issued in early August and subsequent changes could result in the later crews, especially, moving around.

51A, *Discovery*, launch 2 November with Telesat H and Syncom 4-1 communications satellites. Crew: Fred Hauck (cdr), David Walker (plt), Anna Fisher, Dale Gardner and Joseph Allen (all MS). Allen and Gardner have trained for a rescue mission to the Palapa and Westar satellites lost in February.

51C is a Dept. of Defense mission in December with *Challenger*.

51B, *Discovery*, launch 17 January 1985 with the Spacelab 3 life sciences/materials science laboratory. Crew: Robert Overmyer (cdr), Fred Gregory (plt), Don Lind, Norman Thagard and Bill Thornton (all MS), Lodewijk van den Berg and Taylor Wang (both PS).

51E, *Challenger*, launch 12 February 1985 with the Telesat I and TDRS B communications satellites. TDRS B will use an Inertial Upper Stage, which failed during the TDRS A launch in 1983. Crew: Karol Bobko (cdr), Don Williams (plt), Rhea Seddon, Jeffrey Hoffman and David Griggs (all MS), plus Frenchman Patrick Baudry as PS.

51D, *Discovery*, launch 18 March 1985 with the Syncom 4-3 communications satellite. Will retrieve the LDEF released in April 1984's 41C mission. Crew: Dan Brandenstein (cdr), John Creighton (plt), John Fabian, Steven Nagel and Shannon Lucid (all MS), plus a PS from the Hughes company (builders of Syncom).

51F, *Challenger*, launch 17 April 1985 with the Spacelab 2 astronomical payload. Crew: Charles Fullerton (cdr), David Griggs (plt), Story Musgrave, Anthony England and Karl Henize (all MS). Loren Acton (Lockheed) and John-David Bartoe (US Navy civilian) are payload specialists.

51G, *Columbia*, launch 30 May 1985 with the Telstar 3D, Arabsat A and Morelos A communications satellites. Crew: Joe Engle (cdr), Richard Coey (plt), James van Hoften, John Lounge and William Fisher (all MS).

Atlantis, the fourth Shuttle Orbiter, is scheduled to make its first flight in November 1985 with the EOM-1 mission, reflying experiments from Spacelab 1. BIS Fellow Claude Nicollier will be aboard as a mission specialist.

SHUTTLE MISSION 51A

Shuttle flight 51A next month should see two astronauts attempting the daring rescue of the Palapa and Westar 6 satellites lost during mission 41B in February. Orbiter *Discovery* is scheduled for launch on 2 November with astronauts Rick Hauck, David Walker, Joe Allen, Anna Fisher, Dale Gardner and Charles Walker aboard, together with the Telesat H and Syncom 4-1 (Leasat) communications satellites.

The two new craft will be launched first - Telesat using the same PAM type of upper stage that failed in February - and *Discovery* will then manoeuvre to rendezvous with its targets. The satellites will have been brought down to within the Shuttle's grasp and their 50 rpm spin rate reduced to 6 rpm by onboard thrusters. Allen will insert a pole *inside* the used apogee kick motor nozzle of each satellite and fly back to the Orbiter using his Manned Manoeuvering Unit thrusters. The Shuttle's own robot arm will grasp a grappling point on the side of the pole, with Allen still attached, and hold the satellite steady while a frame with another docking attachment is fixed at the top end. The arm can then grab this and lower the satellite nozzle first into the pallet for return to Earth.

Release of the Palapa B-2 satellite during mission 41B last February. The PAM motor that later failed can be seen as the white spheroid under the folded satellite. *NASA*

Palapa and Westar can then be refurbished, adding fresh thruster propellant, kick motors and upper stages, before relaunch over the next year.

The Crew

Captain Rick Hauck of the US Navy is the first group 8 astronaut to command a mission. He previously flew as pilot of STS-7 in June 1983 under Bob Crippen.

David Walker, pilot, was selected as an astronaut in 1978. He entered the US Navy straight from school and eventually became a test pilot at the Naval Air Test Center. This is his first space flight.

Joseph Allen, mission specialist, became an astronaut with the sixth group in 1967 but had to wait until STS-5 in November 1982 to make his first flight. He should have been the first to make a Shuttle EVA but suit problems forced its cancellation on that mission. He has a PhD in Physics.

Anna Fisher, mission specialist, was one of six female astronauts chosen in 1978 and is making her first space flight. She was previously a doctor specialising in emergency medicine in the Los Angeles area. Her husband, Bill, will shortly make a Shuttle flight.

Dale Gardner, mission specialist, is making his second Shuttle flight, having served aboard STS-8 in September 1983.

Charles Walker, payload specialist, is an engineer from the McDonnell-Douglas company and will operate the electrophoresis equipment again in trails to produce purer pharmaceuticals. A member of the BIS, he flew mission 41D in September for the same purpose.

MORE COMMERCIAL ASTRONAUTS

Two engineers from the Hughes Communcations company will fly aboard the Shuttle next year as part of NASA's commercial payload specialist programme, on this occasion deploying the firm's Leasat communications satellites. Hughes has nominated two payload specialists and two alternates for flights 51D in March and 51I in August 1985 to fly with a total of four Leasat (Syncom IV) satellites.

Gregory Jarvis is a member of the Leasat design and engineering team and managed the integration and test team; Dr. John Konrad has been involved with the Intelsat 6 and Telstar 3 programmes. He was also part of the system engineering team for the Shuttle-launched Anik and SBS satellites. The two alternates are William Butterworth and Dr. Steven Lee Cunningham.

ASTRONOMY

HUBBLE TELESCOPE MIRROR CLEANED

Cleaning and remeasurement of the reflectivity of the primary mirror of the Hubble Space Telescope have confirmed that the observatory will have the very best optical system possible. The primary mirror is the principal optical element of the Optical Telescope Assembly of the orbiting observatory, scheduled for launch by the Shuttle in 1986.

In a 16-hour operation, technicians at the Perkin-Elmer Corp. cleaned the 2.4 m primary mirror with fine jets of dry nitrogen and measured its reflectivity at ultraviolet wavelengths. It was found that there had been no degradation since the mirror was coated in December 1981 - performance was still 10% above specification.

Since the mirror was coated, telescope assembly operations have been performed in a special clean room but, even so, a very fine deposit of dust particles had accumulated. The mirror will be installed in the Optical Telescope Assembly shortly.

"This cleaning operation was an important step towards placing the observatory in space," said James B. Odom, manager of the Marshall Center's Space Telescope Project Office. "With the reflectance performance shown to be well above specification, we have increasing confidence that the launch date for the Hubble Telescope will be met in 1986."

The telescope's main mirror is inspected. *NASA*

PIONEER/HALLEY'S COMET

NASA plans to reorient the Pioneer spacecraft now in orbit around Venus to look at Halley's comet in early 1986, as the comet hurtles between Venus and the Sun on its 76-year tour of the Solar System.

Since the Earth will be on the opposite side of the Sun from both Venus and the comet at perihelion, direct observations from our planet will be extremely difficult. But Halley's comet will be easily seen from Pioneer Venus.

Pioneer Venus was launched in 1978 to make a detailed study of Venus and its instruments continue to study atmospheric circulation and other Venus-related phenomena. However, the Halley observation will be only the second time the orbiter will have been moved to observe a comet.

To observe the gases and dust, NASA mission controllers must tilt Pioneer so that its Ultraviolet (UV) Spectrometer can point at the passing comet.

Most atoms emit UV light when exposed to sunlight. By measuring the wavelength and intensity of the emitted light, scientists can determine which elements are present and in what amount.

To practise the necessary manoeuvres mission controllers tilted Pioneer by 37° in mid-April to look across the Solar System at Comet Encke. The results were surprising: Encke was losing water three times faster than expected for its distance from the Sun. This suggests that its constituent materials are not well mixed.

Pioneer spins at 5 rpm as it travels in its orbit around Venus. Engineers will be able to tilt the spacecraft to the desired position by using the seven small thrusters. For Halley, the spin axis will be moved in small increments; a total of 1,000 pulses, each half of a second long, will be used and the entire manoeuvre will cost about half of the usable fuel reserve.

Since the UV Spectrometer has a small field of view and is always rotating it will "see" only a strip of Halley during each spin. However, by tipping the orbiter so that UV Spectrometer can view another area, an image of the entire comet can be built up, strip by strip.

COMMUNICATIONS

NEW DBS SATELLITES

RCA Astro-Electronics are to design and build two high-powered direct-to-home broadcast satellites for the US Satellite Broadcasting Company (USSB) to provide the highest possible quality TV pictures and stereo sound over the 50 states, plus Puerto Rico and the Virgin Islands. Operating at up to 240 W per channel, the satellites will provide a selection of entertainment, sports, education and public affairs programmes on six broadcast channels, backed up by six redundant channels. They will be designed for launch by the Shuttle, Europe's Ariane 4 or by the Atlas Centaur. Since the satellites will be so high-powered, many will be able to pick up signals by way of inexpensive, 60 cm diameter, dish-shaped rooftop antennae.

AIR COMMUNICATIONS

The International Maritime Satellite Organization (Inmarsat) will consider the institutional changes that would enable it to provide satellite communications services to the aeronautical community later this decade.

The Earth Radiation Budget Satellite was due to be released from Shuttle mission 41G in October to study the solar radiation received and re-radiated by the Earth and its atmosphere. *NASA*

This issue was discussed at the 18th Session of the Inmarsat Council, which concluded a week-long meeting in Moscow on 18 July, the first time that it had met in the USSR. It is composed of the 18 Signatories with the largest investment shares in Inmarsat and four others elected to the Council on the basis of geographical representation, with due regard for the interest of developing countries.

Telex traffic handled by Inmarsat is nearly 40% higher than last year, while telephone traffic shows a 70% increase. Ship Earth station comissionings are also at an all time high. A total of nearly 2,700 vessels, from 60 nations, are now commissioned to use the Inmarsat system. There has also been a dramatic increase in the volume of meteorological observations routed by satcom-equipped ships *via* Inmarsat satellites to meteorological authorities. It is felt that Inmarsat could play an increasingly important role in the dissemination of weather forecasts and warnings.

MOBILE COMMUNICATIONS

ESA will proceed with the second phase of the 'Prosat' programme to develop future generations of mobile satellite systems and, in particular, at putting European industry in a strong position when the time comes to prepare the new generations of satellites that will emerge in the early 1990's.

One of the aims of Prosat is the development of smaller maritime terminals with a view to making satellite communications available to all types of shipping, even those of a low tonnage. The programme also aims at developing new services, using the Inmarsat space segment, in both the aeronautical and terrestrial areas. In the latter case, the idea is to study the possibility of setting up a European-wide system enabling, for example, long-distance drivers to remain in permanent contact with their home bases.

SATELLITES

AMPTE TRIPLE LAUNCH

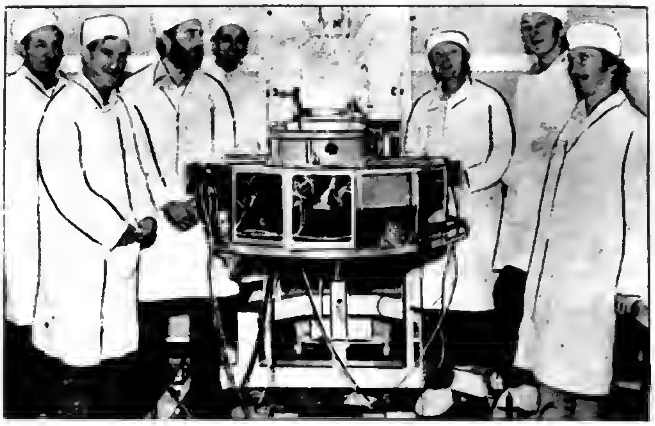
Three satellites designed to play a major role in the study of space plasma physics were launched from Florida on 16 August.

The British satellite, UKS, is a compact but versatile vehicle that will take part in an ambitious series of experiments to explore the complex region of charged particles and magnetic fields (the magnetosphere) that envelopes the Earth out to distances beyond 100,000 km. This region, as well as being of great scientific interest, protects us from the solar wind.

Built jointly by the Rutherford Appleton Laboratory in Oxfordshire and the Mullard Space Science Laboratory of University College London, the spacecraft is the UK contribution to AMPTE (Active Magnetospheric Particle Tracer Explorers) and was completed in the record time of only three years.

The German 'Ion Release Module' will eject canisters of barium and lithium tracer elements for detection by UKS and the US 'Charge Composition Explorer,' patrolling much nearer to Earth.

The magnetosphere is a huge comet-shaped pocket in the solar wind where it interacts with the Earth's magnetic field. Consisting of ionised gas, or plasma, it is fed from the solar wind which streams from the Sun's corona into interplanetary space. Fortunately, 99% of that encoun-



UKS and part of the RAL engineering team. *RAL*

tering the geomagnetic field is deflected, the remaining 1% becoming trapped in the plasma and fields of the magnetosphere. Much is known already about the structure and dynamics of the trapped ions but AMPTE is expected to shed light on the mechanisms that allow penetration of the geomagnetic barrier. Together with the other particles from the radiation belts, these ions are subsequently accelerated and, in some cases in combination with electrons, release their energy in spectacular auroral displays.

In an attempt to explain these phenomena, the German satellite will release relatively small quantities of ions into the solar wind as tracers which will be detected by the American satellite as it moves through the magnetosphere. UKS will keep close to the IRM and make high resolution plasma measurements to help distinguish between temporal changes and spatial structure, an impossible task from a single moving vehicle. The active aspects of AMPTE should be visible from the Pacific area as a man-made comet when barium ions are released in the flank of the magnetosheath in December and, possibly, as additional aurorae when lithium ions are released in the magnetospheric tail. The first release was due in September when a canister of lithium was to be exploded outside the front of the magnetosphere. Between these events and for another six months after the releases, the three spacecraft will apply their advanced instrumentation to studies of the natural particles, fields and waves of the magnetosphere.

The original AMPTE mission involved only the US and German satellites but Britain was later invited to add the smaller UKS craft. The cost of £5 million out of a total project cost of £65 million still ensures that British scientists will share equally in the data.

NOAA OUT OF CONTROL

The NOAA 8 environmental monitoring satellite lost the use of its attitude control system in June and is tumbling in orbit unable to relay its signals effectively to Earth. Launched aboard an Atlas E last year, the 1,700 kg satellites carries six environmental monitoring instruments and a search and rescue payload for the Sarsat/Cospas emergency relay. NOAA 8, the first in a series of three Advanced Tiros N (ATN), began showing a problem on 12 June, according to Charles Thienel, Deputy Metsat Project Manager at NASA's Goddard Space Flight Center. A "clock interrupt" caused the gyros to desynchronise and further disturbances interfered with the meterological instruments, preventing scientists and engineers from obtaining "good" data. "We really haven't had any good data since 13 June," Thienel said. Over the weekend of 30 June, he continued, NOAA 8 began tumbling.

Nitrogen that normally would be available for stabilisation was used shortly after launch from California on 28 March 1983. Following what appeared to be a successful launch, the satellite started tumbling when it reached orbital altitude of 870 km. On 12 April controllers managed to stabilise the spacecraft. The launch of NOAA 9 is now scheduled for 23 October.

US ARIANE BOOKING

The US company Satellite Business Systems has confirmed its intention of launching its SBS 5 satellite on an Ariane 3 in October 1986. The contract comes at a time when Transpace Carriers Inc., the commercial operators of the US Delta rocket, are contesting that the price structure for Ariane launches is unfair, a charge denied by ESA.

The GTE Spacenet communications satellite became the first US Ariane payload when it was successfully orbited on 22 May. SBS 6 is already booked on the Shuttle.

SPACE PROBES

ISPM BECOMES ULYSSES

The joint ESA/NASA International Solar Polar Mission has been renamed Ulysses, a name chosen not only with reference to Homer's mythological hero but also to the Italian poet Dante's description, in the 26th Canto of his Inferno, of Ulysses' urge to explore "an uninhabited world behind the Sun." The mission will, for the first time, permit measurements to be made *in situ* away from the ecliptic plane and over the poles of the Sun, its unique trajectory taking the spacecraft into the uncharted third dimension of the heliosphere.

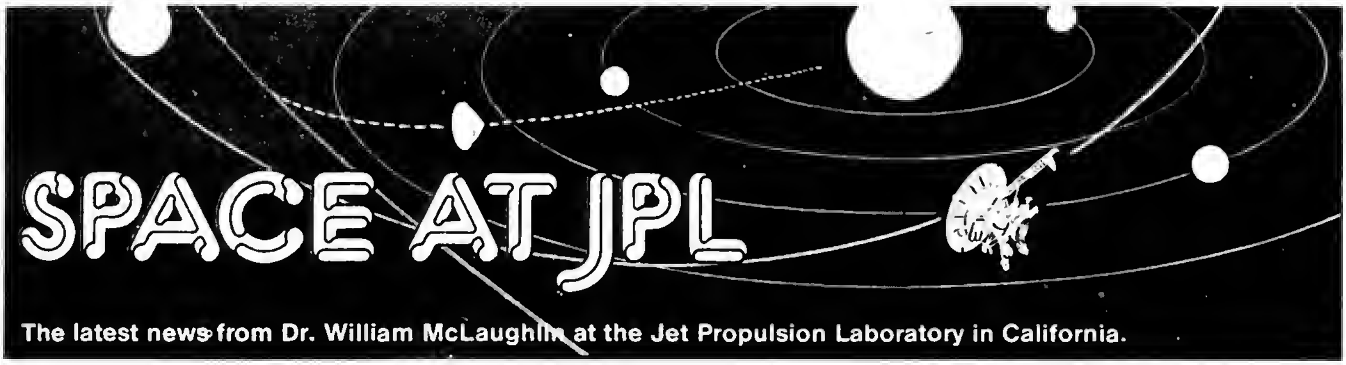
In order to reach its planned out-of-ecliptic orbit at a sufficiently high latitude to enable it to fly over the solar poles, Ulysses will be launched by the Shuttle in May 1986 into an elliptic transfer orbit to Jupiter, which it will reach about 14 months later. The planet's gravitational field will deflect it into a high-inclination orbit, out of the ecliptic plane. Some two and a half years later, it will make its first passage over one of the poles of the Sun. It will then recross the plane of the ecliptic on its way to the other pole, which it should cross about eight months later. The whole mission is due to last for five years.

The primary objective is to investigate the properties of the solar wind, the structure of the Sun/wind interface, the heliosphere magnetic field, the interplanetary magnetic field, the solar wind plasma, solar and galactic cosmic rays and cosmic dust. In addition, interplanetary physics investigations will be carried out during the cruise between Earth and Jupiter.

OTHER NEWS

SPACE EXHIBITION

A Finnish member, Tero Siili, tells us that the 'Space 2000' exhibition in the town of Espro, near Helsinki, in Finland opened in July with a full-scale representation of Salyut-Soyuz-Progress. Other exhibits in the display of Soviet space technology included Molniya and Meteor satellites, a Lunokhod Moon rover, Mars and Venus probes and space suits.



COMETS ABOUT VEGA?

Shells of particulate matter were discovered about the stars Vega and Formalhaut from observations taken in 1983 by the Infrared Astronomical Satellite (IRAS) (see the December 1983 and April 1984 issues). More recent analysis of the IRAS data indicates that perhaps 20% of the stars in the solar neighbourhood may be surrounded by shells of this type.

Dr. Paul Weissman, a JPL planetary scientist, writing in the 1 June issue of *Science*, has suggested that the shell about Vega consists of cometary bodies that total a mass of at least 15 times that of the Earth. Furthermore, he concludes, there is some evidence from the IRAS observations that an asteroid belt may also encircle Vega, closer to the star than the hypothesised cloud of comets.

It has been argued that a cloud of comets exists in the outer Solar System (the Oort cloud) named after the Dutch Astronomer Jan Oort who first proposed the idea in 1950. By Oort's theory comets that appear in the inner Solar System are derived from this distant and cold storehouse.

If the Vega system and our Solar System share some structural features, one naturally wonders if Vega also has a planetary accompaniment. However, the IRAS telescope could not resolve images down to this fine level of detail so that answer must await the introduction of larger instruments.

THE FLASH OF SUNLIGHT

It is reported that in the Third Century BC Archimedes used the rays of the Sun, focused with the aid of a large mirror, to ignite ships of the Roman fleet in defence of his native Syracuse.

Specular (or mirror) reflection has been used more often in the service of vanity or science rather than for direct military action. The virtue of a mirror, flat or shaped, is that it provides one of the best methods for collecting and redirecting rays of light. When shaped in the form of a paraboloid it can serve as the primary mirror for a reflecting telescope.

The advanced-concept review for this month addresses some applications of the principle of specular reflection to space missions.

The most dramatic use to date of specular reflection resulted from an experiment devised by Harold Liemohn wherein sunlight was reflected from the solar panels of Lunar Orbiter V so as to be detected and photographed by a large Earth-based telescope (see the April 1968 *Sky and Telescope* for details). Numerous specular flashes were also seen from polished surfaces of the Apollo spacecraft as these vehicles were observed telescopically during their journeys to the Moon and back; see "One Eye at the Telescope" in January 1983's *Spaceflight*.

What is the future of specular reflection? Its great merit is that it allows the rather precise location of a distant object with the expenditure of minimal effort and resources. One application involves placing a small mirror atop a landed spacecraft. With proper orientation, the lander can then be precisely located with respect to topographic features by a spacecraft orbiting overhead even though the orbiter's sensors cannot observe the small lander *per se* (this application was suggested in 1972 by the author for the Viking mission, but schedule pressures precluded its use). The application was demonstrated practically by William Evans in 1974 using a mirror in his backyard to flash the Landsat satellite orbiting overhead (*Photogrammetric Engineering*, **40**, June 1974).

The distance at which a relatively small mirror can be seen by reflected sunlight is truly astounding. A mirror with an area of 1 m^2 could be seen through a very large telescope at a distance beyond Pluto's orbit!

An interesting navigational application of this can be envisaged during the approach of a spacecraft to a faint asteroid or comet. The location of the targeted asteroid or comet would not necessarily be well known with respect to the spacecraft; the ephemerides of small Solar System bodies are frequently of an approximate nature. However, it would be highly desirable to view the target with the spacecraft's camera system as soon as possible in order to navigate accurately into the vicinity of the object. If the spacecraft, augmented with a mirror, and the target were both viewed simultaneously from Earth, perhaps with a wide-field Schmidt telescope, this additional information would narrow the region of search that the spacecraft's cameras need inspect (geometrically: spacecraft, target and telescope would have been determined to lie in a known planar surface).

However useful such technical applications prove, the

This picture of Lunar Orbiter V was taken on 21 January 1968 by the 150 cm telescope at the University of Arizona. This 10 second exposure was part of a set of 52 showing the craft as a 12th magnitude object as it orbited the Moon.

simple pleasure of seeing our small spacecraft drifting toward rendezvous with a comet might be the real payoff.

A scientific application of specular reflection would be to use it to measure the optical transmission properties of various Solar System objects. For example, a planetary atmospheric probe could be equipped with specular capability and observed from a nearby second spacecraft as the probe plunged to extinction into the atmosphere. Similarly, two spacecraft could explore the optical properties of Saturn's rings.

IMAGES OF NEPTUNE

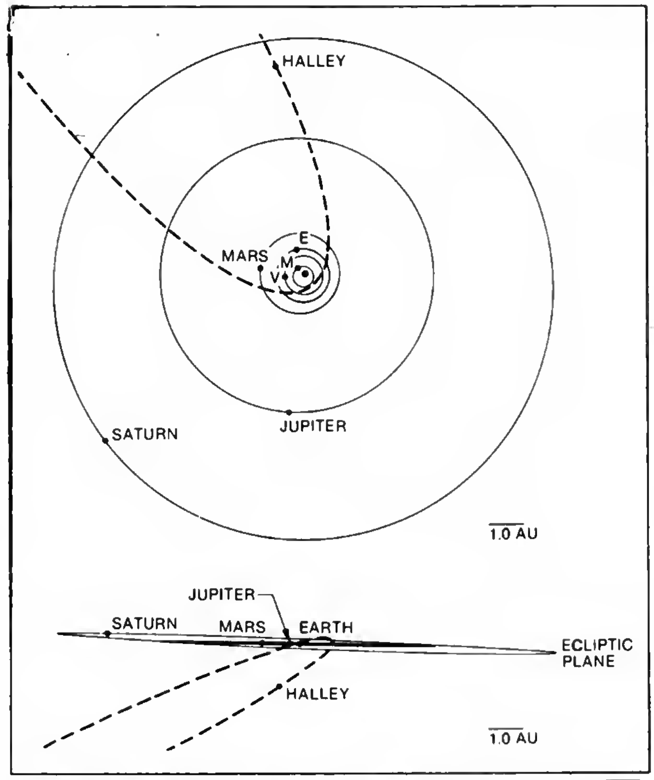
The best images of Neptune this century should be obtained by the Voyager 2 spacecraft as it flies past the planet in August 1989. Some of the best Earth-based images of Neptune ever recorded have been obtained using the 2.5 m reflector at the Carnegie Institution's Las Campanas Observatory in Chile. The observations were made by Dr. Richard Terrile of JPL and Dr. Bradford Smith of the University of Arizona.

Special techniques must be used to bring out any detail on distant Neptune: Terrile and Smith employed a sensitive charge-coupled device (CCD) and a planetary coronagraph with the telescope to get the images on 25 May 1983 in the 8900 Å wavelength band. In addition, special image processing was done at JPL by Charles Avis.

Three large features, each about the size of the Earth, were visible as they were carried along by the rotation of the planet. The rotation rate deduced from the motion of these is about 17 h 50 m and is the first time that Neptune's rotation has been directly observed. The features are probably caused by sunlight reflected off clouds of methane ice crystals elevated above the planet's gaseous methane atmosphere.

PHOTOMETRY OF HALLEY'S COMET

Halley's comet was recovered in October 1982 using the 5 m telescope at Palomar, as described in February 1983's 'Space at JPL.' Since then, several other photographs of the comet have been taken as it slowly brightens during its approach to the Sun. Of particular interest are three photographs taken in January 1984 through the 5 m telescope by Drs. David Jeweitt of MIT and G. Edward Danielson of Caltech.



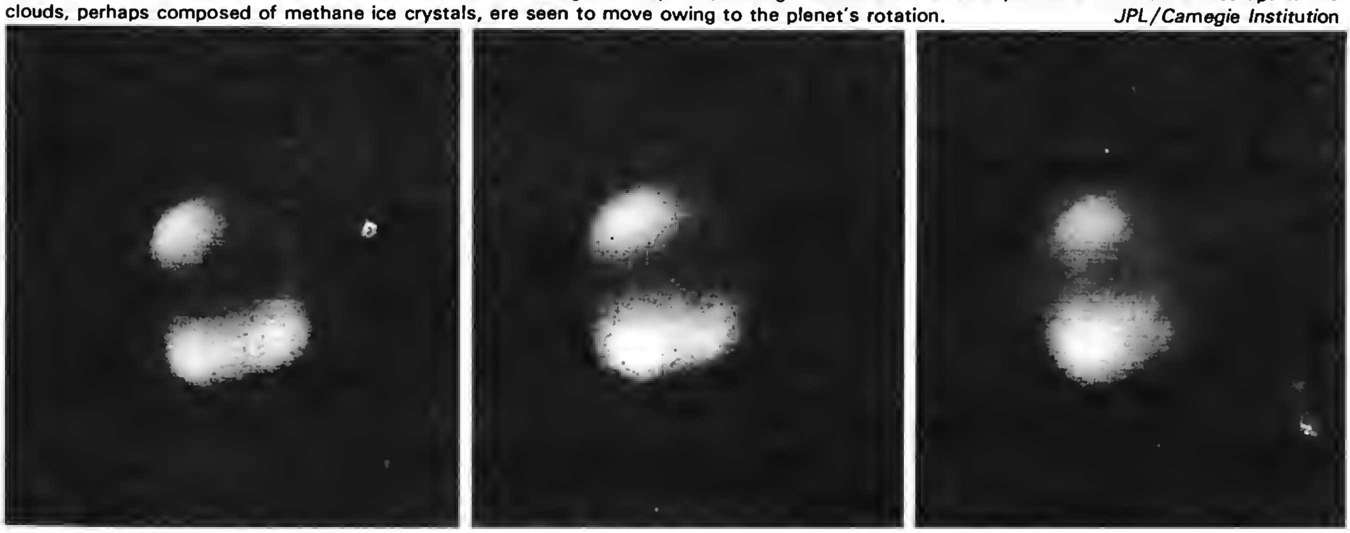
These two views show the position of Halley's comet and six planets on 7 January 1984 when the comet was imaged with the 5 m telescope at Palomar. *JPL/NASA*

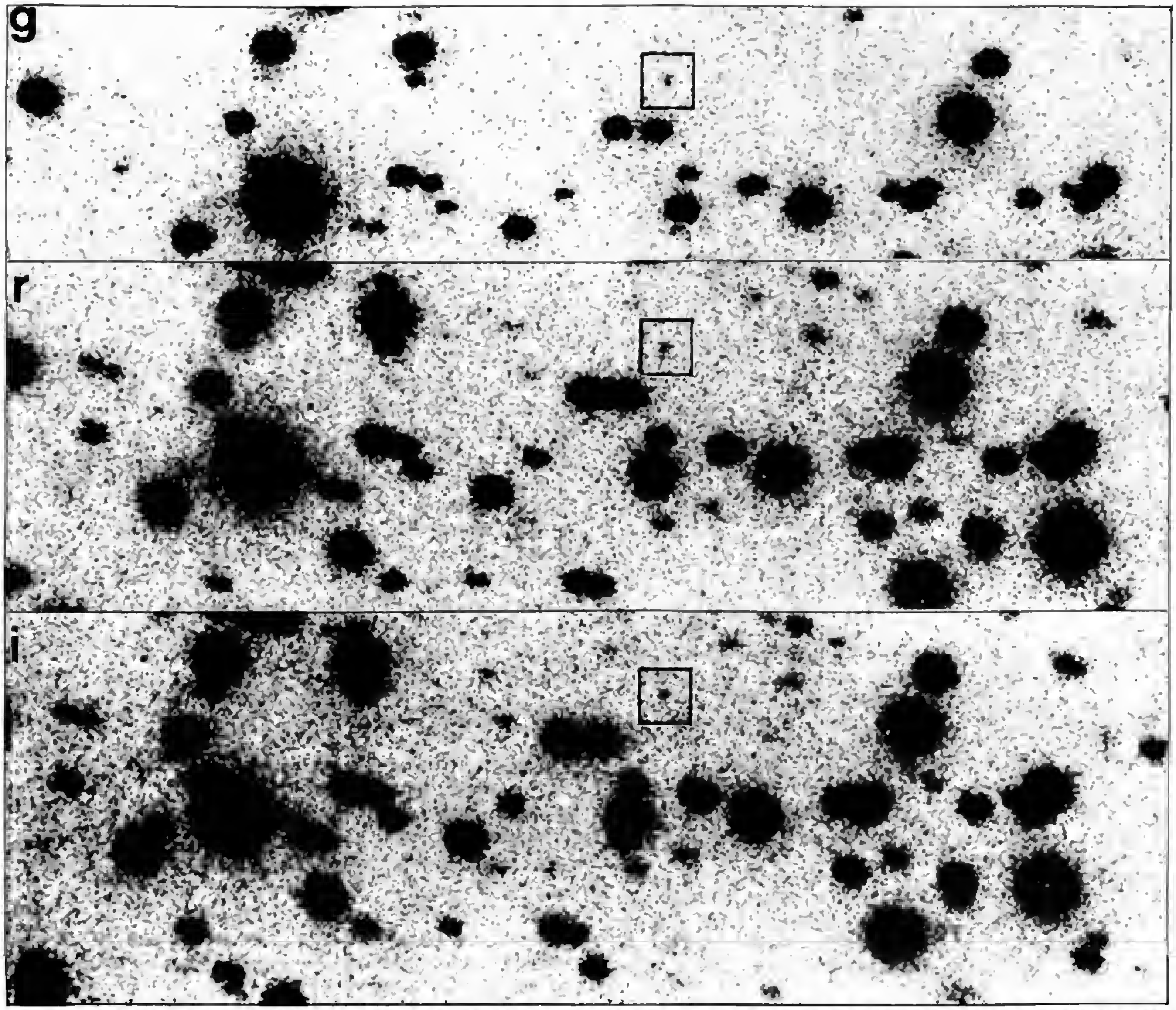
The distance of the comet was 8.2 AU at the time (1 AU, or astronomical unit, is the average distance from Earth to Sun) and had a stellar magnitude of only 23. The image appeared as a point of light with no coma apparent around the nucleus, but a very faint one could exist and remain undetected. As Halley approaches the Sun more closely it will, of course, develop a significant coma and tail.

The three photographs were taken with three different filters (centred in the green at 0.50 microns, in the red at 0.65 microns and in the infrared at 0.80 microns) in order to obtain an idea of the 'colour' of the comet; it appeared to be consistent with an object viewed by reflected sunlight; that is, it was not introducing a bias to the sunlight.

Jewitt and Danielson noted that Comet Halley is varying in brightness by about one magnitude on a timescale of one day or less. They conclude that this variation could

Bright cloud-like features ere seen in each of these three images of Neptune, among the best ever recorded, taken about 45 minutes apart. The clouds, perhaps composed of methane ice crystals, ere seen to move owing to the plenet's rotation. *JPL/Carnegie Institution*





Three images, taken in January 1984, show Halley's comet as it moves closer to the Sun. The comet is enclosed in a box of 8 arcsecond width in each case. North is towards the bottom, east to the left. From top to bottom the images were taken in red, green and infrared, respectively, using a charge-coupled device (CCD) with the 5 m telescope at Palomar. *Palomar Observatory*

either be due to ejection of material from the comet or rotation of the nucleus, which might be irregular in shape or albedo.

SYSTEMS ANALYSIS

A check of the list of technical and administrative sections at JPL reveals that about 20% have some form of the word "system" in their name. This is clear linguistic evidence that the Laboratory takes the practice of systems analysis and engineering seriously. Of course, this attitude is shared with much of the modern world as the systems approach has become a primary mover of large and small enterprises.

What is a system? It is a group of related components that exchange information and energy among themselves and with their environment, and it exists for the accomplishment of a definite set of purposes.

This is a rather general description with lots of loose ends and undefined terms, but volumes have been written on the subject without achieving a widely-accepted definition. Probably the best known work on the subject is C. West Churchman's 1968 classic, *The Systems Approach.* Published in the heart of the Apollo era, this treatise has exerted an enormous influence on engineering (and business) procedures in the United States. To find a broad, analytical book with comparable impact, one might have to go back to 1933 and Alfred Korzybski's *Science and Sanity,* which brought general semantics to prominence.

It is not immediately apparent why the systems approach has proved so effective. Perhaps it derives simply from the fact that it continually invokes planning, one of man's most powerful tools. Another explanation is that the systems approach emphasises the value of achieving an overview, 'the big picture,' and circumvents the tendency to get lost in a welter of details.

As important as both of these considerations are, there is another, more primitive, factor that may be providing the spark: the analogy of a system with a living organism. A successful organism is a collection of subsystems that survive and prosper: precisely those attributes we try to design into our engineering creations. According to this hypothesis, the systems approach provides a biological paradigm for which we have, literally, a visceral understanding.

Thus, systems analysis and engineering is an activity guided by a set of patterns developed during nearly 4,000 million years of evolution.

NEWS FROM THE CAPE

The Latest Developments from Cape Canaveral in Florida

By Gordon L. Harris

SHUTTLE CRITIQUE

The 1 July issue of the *New York Times* assessed the current status of NASA's Shuttle programme and cited the reasons why the outlook has been clouded:

- On 25 and 26 June attempts to launch Mission 41D were unsuccessful.
- "Concern over the reusable spacecraft centers on their ability to deliver goods on time and often. In that respect, the shuttles have not lived up to advance billing as a means of making space flight regular, routine and economical."
- Several commercial customers for Shuttle services were already restive. Some such as Intelsat and General Telephone Corp., reserved space on ESA's Ariane rockets."
- The most significant defection could be that of the Defense Department whose payloads constitute one quarter of Shuttle cargoes. It was the Pentagon's political muscle that carried the programme through a critical period in the late 1970s when everything was going wrong and Congressional support was waning. Because the planned fleet of five Shuttles was supposed to be the nation's primary space transportation system, Air Force had been told to phase out conventional rockets..."
- "Any thought of abandoning expendable rockets has vanished. because of Shuttle development delays and diminished faith in its ability to handle all orbital traffic. The Reagan Administration is clearing the way for private industry to produce and operate Delta and Atlas rockets for commercial customers, the Air Force is asking Congress for money to develop a new line of expendable boosters."
- The US Air Force has told Congress that it cannot rely on the Shuttle because "original expectations are not being fulfilled because the Shuttle is much more complex than originally envisioned, requires more maintenance between flights than planned and, with payloads integration more time consuming and technically difficult..!"

The *Times* recalled NASA's optimistic forecast of two-week turnarounds noting that "no-one speaks of that any more; two months, often longer, is the norm."

- "And although charges for shuttle cargoes are at loss-leader rates, NASA has yet to demonstrate when rates reflect real costs, it will be less expensive to fly Shuttles than conventional rockets."
- "Launch postponements and customer defections have put NASA in a real bind. Until Shuttles fly often enough they cannot be proven economic, but if they lose too many customers they will not fly often enough."

Yet Jesse Moore, who succeeded Lt. Gen. Abrahamson as Shuttle manager, said "We're hoping to get these bugs out of the system as quickly as we can. I would hope our customers are sophisticated enough to know that redundancy, which was responsible for the shutdown [on mission 41D], is built in to minimise the probability of greater failures."

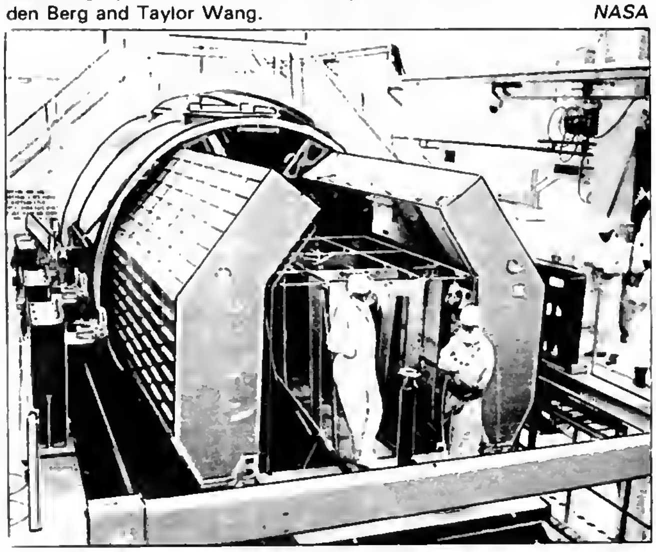
'Bugs' forced the agency to cut three launches from 1984's schedule of 10. The plan is to launch 13 in 1985, 15 in 1986 and 24 in 1987 using Pads A and B at the Kennedy Space Center and one at Vandenberg Air Force Base in California.

41D's NON-LAUNCH

Mission 41D, heralded as *Discovery's* debut, became NASA's No. 1 embarrassment since the Shuttle programme attained operational status. The first launch attempt on June 25 stopped at T-9 minutes when the five computers that control the ship disagreed. Next day, the press, guests, TV networks and the public gasped when the three main engines cutoff at T-4 seconds.

As flames appeared under the tail, burning off free hydrogen, and water poured across the pad, a temperature of 750°C was reported. The huge vehicle stood motionless, its tanks filled with liquid hydrogen and oxygen, its six-member crew unable to exit. ABC TV's Lynn Sherr, face on to her camera, assured viewers "the crew is completely safe" - obviously she did not understand the actual hazards. It was 45 minutes later before the disappointed astronauts left their crippled ship. NASA had escaped catastrophe by a narrow margin.

The experiment racks are slid into the pressure shell in preparation for the Spacelab 3 flight next January. The crew will be Robert Overmyer, Fred Gregory, Don Lind, Norman Thagard, Bill Thornton, Lodewijk van den Berg and Taylor Wang. *NASA*



THROUGH THE TAIL OF A COMET

By Dr. William I. McLaughlin*

The first space mission for cometary exploration will be conducted by the International Cometary Explorer (ICE). The craft will pass through the tail of Comet Giacobini-Zinner on 11 September 1985, some 10,000 km from the nucleus. Its instruments consist of fields and particles experiments (no imaging) which will provide an *in situ* study of the comet and its interaction with the solar wind.

Introduction

The spacecraft, originally the International Sun-Earth Explorer 3 (ISEE-3), was launched on 12 August 1978 and placed between the Sun and the Earth-Moon system mainly to measure properties of the solar wind. In June 1982 a complex series of manoeuvres was started by controllers at the Goddard Space Flight Center using onboard propellant and gravity assists from the Earth and Moon to move ICE from its solar monitoring post to, eventually, the region of Giacobini-Zinner. ICE will also assist in the international study of Halley's comet by measuring the solar wind upstream of that body in late 1985/early 1986.

Cometary Exploration

The classical pattern for planetary exploration consists of several phases: Earth-based exploration; flyby; orbiting and possible delivery of an atmospheric probe; landing on the surface; manned exploration and possible colonization. Only in the case of the Moon has this route been fully followed, while Martian exploration has reached the landing stage with Viking and Galileo will bring Jovian investigation to stage 3 (orbiter and probe).

Earth-based study of comets is a well-developed branch of astronomy. The next phase, flyby, is illustrated by ICE and the international armada of five probes that will explore Halley's comet in 1986 [1]. A phase can be inserted between Earth-based observations and flybys: remote sensing by spacecraft. ICE will do this for Halley's comet, as will several other craft, including Pioneers 7, 9 and 12, the International Ultraviolet Explorer and the newly-repaired Solar Max.

Plans are already underway for the third phase of cometary exploration: rendezvous with and orbiting of the nucleus. The first of JPL's proposed Mariner Mark II missions will meet Comet Kopff and study it for an extended period [2]. Finally, landing on the nucleus of a comet, extracting a sample and returning it to Earth for study in the laboratory should be feasible sometime around the turn of the century. Again, it is possible to make insertions between phases, in this case between simple flyby and rendezvous or rendezvous and landing with a fast flyby that scoops up samples using various collection devices, including styrofoam [3].

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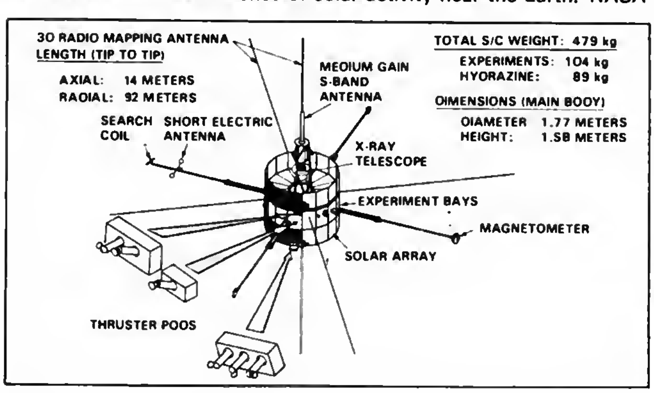
Comet Giacobini-Zinner, with its ion tail, is shown in this 26 October 1959 photograph by Elizabeth Roemer. *US Naval Observatory*

ISEE-3 was designed originally to conduct fields and particles experiments related to the influence of solar activity near the Earth. *NASA*

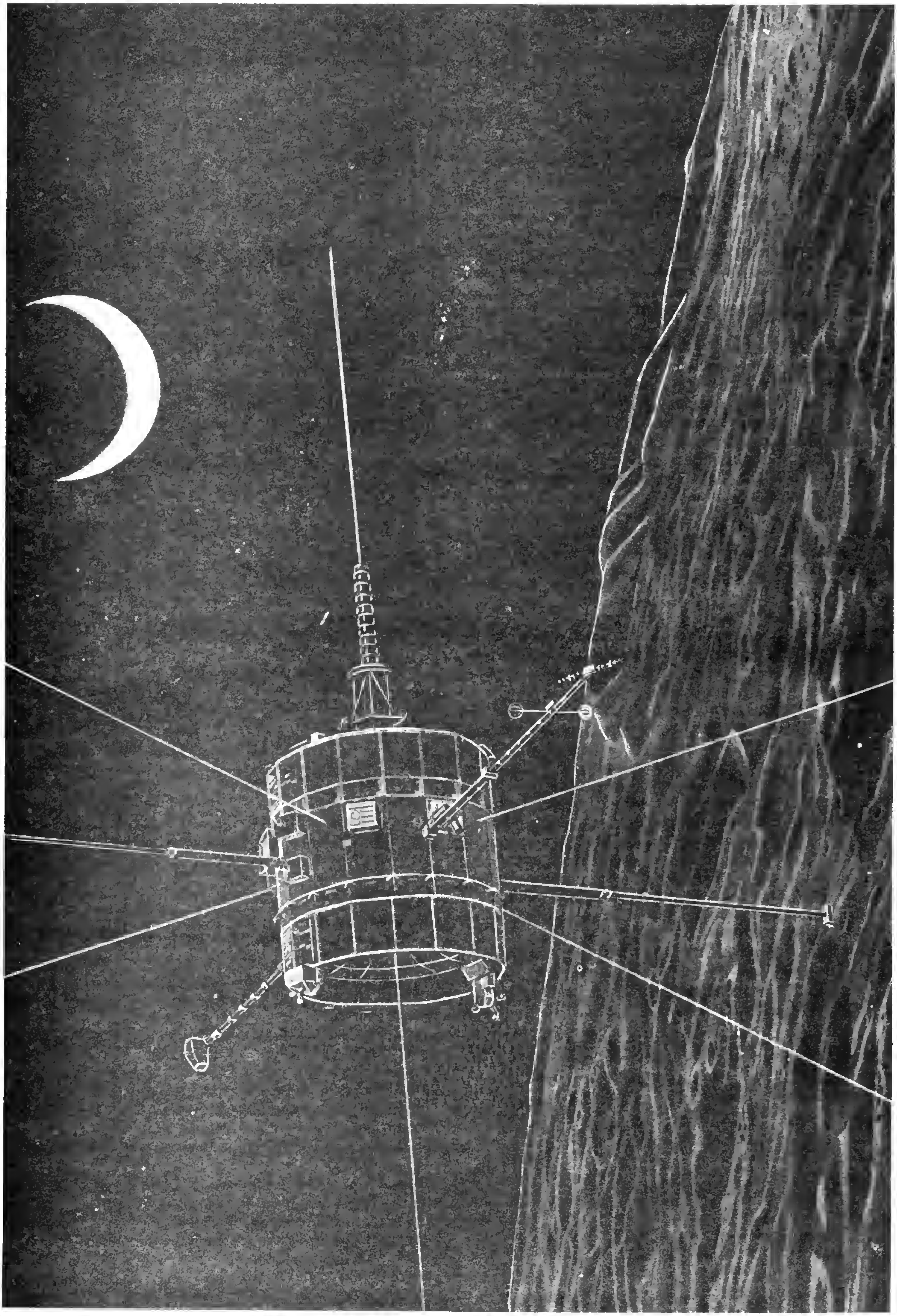


Creating ICE

For its original mission, ISEE-3 was placed in a "halo orbit" around the Sun-Earth libration point, L1, between the Sun and Earth, 1.5 million km from the latter body [4]. This is one of several points about which the gravitational forces balance and a spacecraft can be 'parked.' The theory of such points was worked out by Lagrange in 1772 (hence the "L"); two of the Lagrange points in the Sun-Jupiter system harbour the so-called Trojan asteroids.

At its position ISEE-3 was able to sense the solar wind and transient phenomena such as solar flares about an hour before they affected the Earth.

In one of the most imaginative ideas yet in space mission design, Dr. Robert Farquhar of NASA's Goddard Space Flight Center proposed the redeployment of ISEE-3 to Comet Giacobini-Zinner. The germ of the idea was there before launch and Farquhar had urged the craft's designers to include ample onboard propellant in order to keep the options open [5]; at one time he considered transferring ISEE-3 to Halley's comet, but calculations done at JPL showed that the communications range would be too great to return useful data. The successful



design of the link for ICE at Giacobini-Zinner was due in large part to the work of Dr. Joel Smith and Warren Martin of JPL's Office of Telecommunications and Data Acquisition.

Despite the evident attraction of Farquhar's proposal for an early and extremely cost-effective cometary mission, intensive study and negotiations remained before NASA Headquarters gave final approval. Three basic options were considered:

1. Leave ISEE-3 in its halo orbit to continue its original mission.
2. Move ISEE-3 from its halo orbit into the "geotail" (Earth's magnetic field tail) region, downstream in the solar wind for 6 to 12 months and then back to the halo orbit.
3. Explore the geotail region as in (2) but then proceed to Giacobini-Zinner instead of returning to the halo orbit.

These options were examined by NASA Headquarters, GSFC (manager and operator of ISEE-3), the Space Science Board of the National Academy of Sciences and the Comet Subcommittee of the ISEE Science Working Team. According to Dr. Edward Smith of JPL, who chaired the eight-member Comet Subcommittee, the eventual decision to go with option (3) was reached because it would result in "new science" and would achieve one of the primary objectives of cometary science: "to investigate the interaction between the solar wind and the cometary atmosphere" [6].

ICE had been born.

Spacecraft and Intruments

The spacecraft is normally spin stabilised at 20 rpm - suitable for the fields and particles experiments.

Both trajectory adjustments and attitude control use a hydrazine propulsion system. The initial 89 kg of propellant (at launch) correspond to a change in velocity (ΔV) of about 430 m/s. As of 1 January 1983 64 kg of propellant remained (300 m/s).

In its original position at the libration point, 1.5 million km from Earth, ISEE returned data with its S-band system at 2 kilobits per second, normally to a 26 m Earth station. During the Giacobini-Zinner encounter, at a range of 70 million km, the rate will be 1/2 to 1 kbits/s to the 64 m antennae of the Deep Space Network (DSN) managed by JPL.

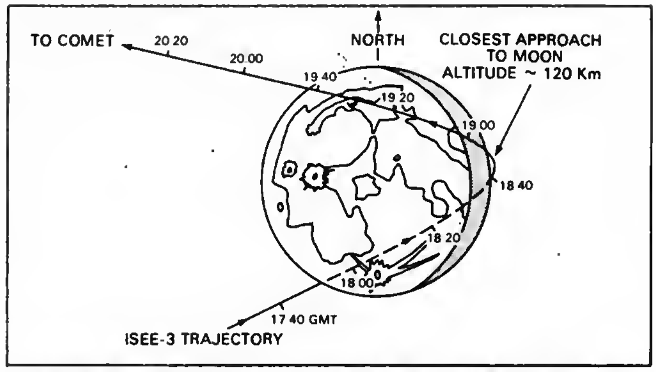
Electrical power is generated for the communications and other subsystems by solar cells.

The ISEE-3 set of experiments is listed in Table 1; the first six are relevant to the comet encounter.

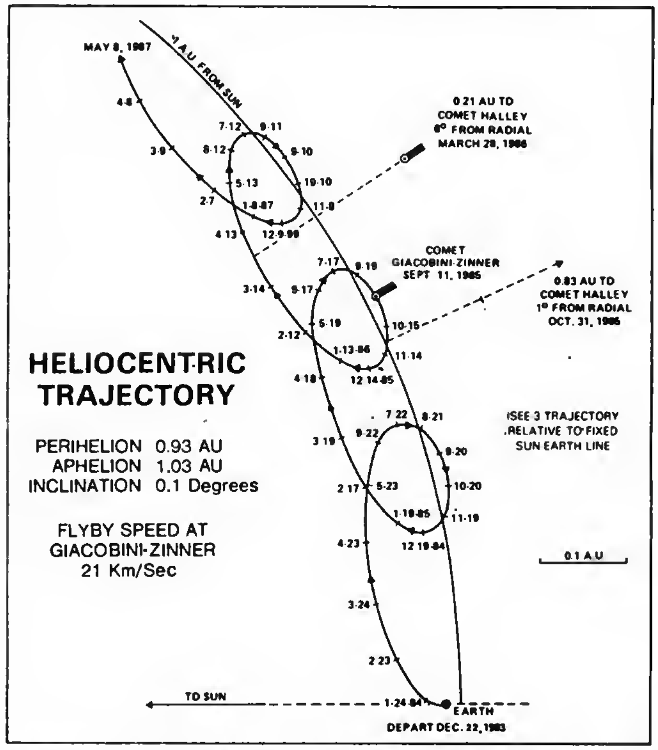
As ICE approaches Giacobini-Zinner its instruments should be able to detect the transition region between the comet and the solar wind. Here, particles from the Sun and the comet mix together and solar magnetic field lines adjust themselves to drape over the comet like ropes. It might take ICE five days to cross this region.

Plunging into the comet's tail, ICE will find the heavier particles native to the comet (the solar wind plasma is composed primarily of protons and electrons). Information on the distribution of dust within the tail could come as the electric dipole antennae of the plasma wave experiment are struck during the day-long crossing of this region.

ISEE/ICE as it flies to within 116 km of the Moon's surface on 22 December 1983 in order to receive a gravity assist that boosted it towards the meeting with Giacobini-Zinner. NASA



ICE's path, as seen from Earth, during its very close flyby of the Moon. *NASA*



The looping ICE path is shown with respect to the Earth's orbit. Note the two occasions (31 October and 28 March) when the spacecraft will be almost directly upstream of Halley's comet and able to sample the solar wind ahead of it. *NASA*

Trajectory

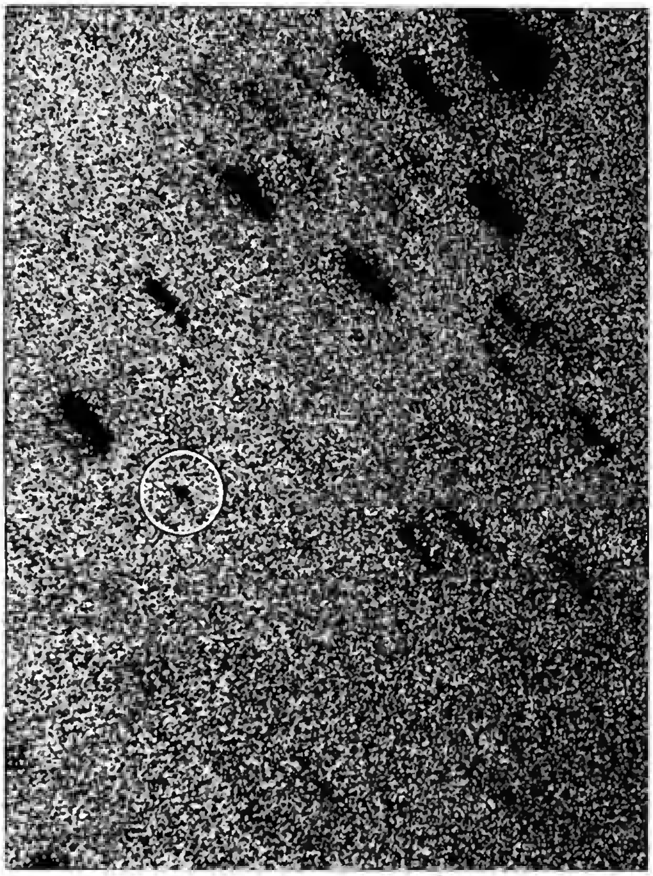
The path designed by Farquhar and colleagues at Goddard and the Computer Sciences Corporation will probably be the most complex application yet of celestial mechanics.

The key idea is to apply carefully-timed engine firings and a series of five lunar flybys to achieve gravity assists [1,7]. The trajectory is shaped by journeys past the Moon's leading edge (which take energy from ICE) and past its trailing edge (which add energy).

The final, dramatic flyby took place on 22 December 1983 when ICE passed just 116 km over the surface of the Moon in the region of Smyth's Sea, not far from Tranquility Base (Apollo 11 landing site). In addition to the navigational finesse, ICE spent almost 30 minutes flying through the Moon's shadow.

During this time there was some danger that hydrazine could freeze in the supply lines, causing structural damage. However, engineers turned on heaters before shadow entry and ICE emerged intact.

As ICE proceeds on its path to the comet, navigational work (orbit determination, trajectory corrections) is being performed by a small group of navigators at JPL, headed by Dr. Leonard Efron.



The recovery of Giacobini-Zinner on 3 April 1984, from the Kitt Peak National Observatory by S. Djovgovski and H. Spinrad (University of California, Berkeley), and G. Will and M.J.S. Belton (Kitt Peak National Observatory). The elongated images are stars smeared out as the telescope tracks the predicted motion of the comet.
National Optical Astronomy Observatories

Table 1. ISEE-3/ICE Experiments. The first six experiments will return useful information at Comet Giacobini-Zinner.

TITLE	PRINCIPAL INVESTIGATOR	AFFILIATION	EXPERIMENT STATUS
Solar Wind Plasma	Bame	Los Alamos National Lab	Electrons Only (Ion Portion failed)
Plasma Composition	Ogilvie	GSFC	Operational
Magnetometer	Smith	JPL	Operational
Plasma Waves	Scarf	TRW Systems	Operational
Energetic Protons	Hynds	Imperial College London	Operational
Radio Waves	Steinberg	Paris Observatory Meudon	Operational
X-Rays, Low Energy Electrons	Anderson	UCB	X-Rays and E_e > 200 keV (Low energy electron portion failed)
Low Energy Cosmic Rays	Hovestadt	MPI	Partial Failure (ULEZEQ)
Medium Energy Cosmic Rays	Von Rosenvinge	GSFC	Operational
High Energy Cosmic Rays	Stone	CIT	Partial Failure (Isotope Portion)
High Energy Cosmic Rays	Heckman	UCB/LBL	Partial Failure (Drift Chamber)
Cosmic Ray Electrons	Meyer	University of Chicago	Operational
Gamma Ray Bursts	Teegarden	GSFC	Partial Failure (PHA Memory)

Comet Giacobini-Zinner

The short-period comet Giacobini-Zinner was discovered in 1900 by M. Giacobini and accidentally rediscovered in 1913 by E. Zinner [8,9].

Travelling in an orbit that brings it to perihelion slightly further from the Sun than the Earth, about every 6½ years, the comet is remarkable for its well-developed tail. Most short period comets such as Encke or Pons-Winnecke have lost so much material over the ages that they cannot produce much of a display.

Giacobini-Zinner was recovered with the 4 m telescope at the Kitt Peak National Observatory on 3 April 1984 as it approached the inner Solar System. Previous ICE manoeuvres had been predicated on the comet appearing basically as planned. However, there is always an uncertainty in cometary orbits due to non-gravitational forces (such as random jetting of material from the nucleus), and it was good news that the predicted ephemeris furnished by Dr. Donald Yeomans was a very accurate fit to Giacobini-Zinner's path for this apparition [10]. The time of perihelion passage, for example, differs by only 0.01 days from that predicted by Yeomans (see Table 2; note the obvious effect of improvements in astronomical instrumentation as the comet has been generally recovered at greater distances at succeeding apparitions).

The radius of the nucleus may be about 1 km. Compared to Comet Encke it is also rather dusty; for example, at 38,000 km it is dustier by a factor of 50 [11].

An interesting opportunity for observation with moderate-sized telescopes will occur on 15 September 1985 when Halley and Giacobini-Zinner will be separated by less than 2° on the celestial sphere. Giacobini-Zinner should then have a magnitude of about 8 while Halley will be fainter at mag 12 (under good conditions the average human eye can see to about mag 6).

In its returns of 1933 and 1946, Giacobini-Zinner brought with it a spectacular display of meteors (the author well remembers the 1946 display), while other apparitions have resulted in very few meteors [12]. The comet is evidently followed in its orbit by a large amount of debris. Two conditions must be satisfied in order to experience a meteor storm:

1. the Earth must pass closely behind Comet Giacobini-Zinner, and
2. the Earth must pass close to the orbit of the comet so as to intersect a small "tube" (whose dimensions are not exactly known) within which most of the meteoroids lie.

In 1933 the Earth arrived at the descending node of the comet's orbit 80.2 days after the comet passed that point, while in 1946 it was 15.4 days. In 1985, it will be 26.5 days; somewhat further behind the comet than in 1946, but closer than in 1933. The 1985 apparition will see the Earth pass 0.03 AU from the comet's orbit (1 AU, or astronomical unit, is the mean distance from Earth to Sun, about 150 million km). This is farther than the 0.0054 AU passage of 1933 or the 0.0015 AU one of 1946.

Thus, if the tube with the bulk of the debris has a radius greater than 0.03 AU, we are likely to see a lot of meteors. If that zone is thinner, very few may result. The best viewing will be at 8.55 GMT on 8 October 1985. According to Yeomans' prediction, the radiant (the point from which the meteors will appear to emanate) is at declination 57.1°N and right ascension 260.6° (1950.0 coordinates) in the constellation Draco. These meteors are thus sometimes referred to as "the Draconids."

It remains to be seen if spaceship Earth will be as fortunate in its exploration of Giacobini-Zinner as its junior colleague, ICE.

Acknowledgements

The author appreciates the assistance of Dr. Robert Farquhar of GSFC and Dr. Donald Yeomans of JPL in

Table 2. Recovery conditions for Comet Giacobini-Zinner, 1900 to 1984 apparitions. Courtesy of D.K. Yeomans.

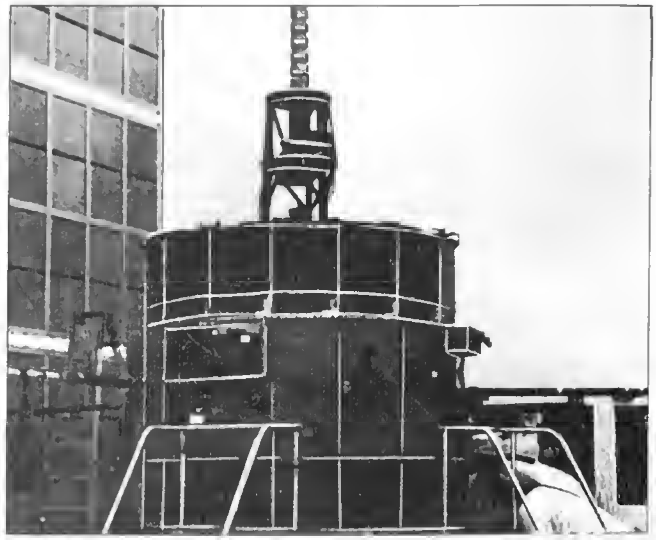
Year	Perihelion Passage	Observational Interval	r	Δ	m	ΔT
1900 III	1900 Nov. 28.496	1900 Dec. 20-1901 Feb. 16	1.02	0.93	10.5	
1913 V	1913 Nov. 02.567	1913 Oct. 23-1913 Dec. 27	0.98	0.60	10.0	
1926 VI	1926 Dec. 11.708	1926 Oct. 06-1927 Mar. 04	1.36	1.44	14.0	
1933 III	1933 Jul. 15.147	1933 Apr. 23-1933 Oct. 18	1.52	1.64	15.0	-1.18
1940 I	1940 Feb. 17.211	1939 Oct. 15-1939 Oct. 16	1.90	2.44	15.0	-0.07
1946 V	1946 Sep. 18.486	1946 May 26-1947 Jan. 24	1.80	1.19	17.0	-0.15
1959 VIII	1959 Oct. 26.919	1959 May 08-1960 Apr. 25	2.30	1.61	20.0	+1.10
1966 I	1966 Mar. 28.291	1965 Sep. 17-1965 Sep. 25	2.52	2.98	19.8	+0.09
1972 VI	1972 Aug. 04.897	1972 Mar. 11-1973 Feb. 06	2.30	2.11	18.8	-0.06
1979 III	1978 Feb. 12.776	1978 Apr. 30-1978 Oct. 03	3.25	2.36	20.5	-0.14
1984e	1985 Sep. 05.259	1984 Apr. 03 -	4.55	3.66	24	+0.01

r = heliocentric distance of comet (A.U.) at recovery

Δ = geocentric distance of comet (A.U.) at recovery

m = apparent magnitude of comet at recovery

ΔT = correction in days required for predicted time of perihelion passage (observed minus calculated)



ISEE-3 is prepared for launch in 1978 by a Delta rocket. *NASA*

supplying information concerning the mission and the comet, respectively. The work on this paper was carried out by the Jet Propulsion Laboratory, California Institute of Technology, under NASA Contract.

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HALLEY'S COMET OBSERVATIONS

NASA is preparing to observe Halley's comet in 1986 using a Shuttle-based astronomy observatory called Astro. It consists of three ultraviolet telescopes and two wide-field cameras that will be carried as a Spacelab payload in the Shuttle's cargo bay.

Astro will fly on a series of missions to study stars and galaxies in ultraviolet light; the two cameras have been added specially to observe Halley's tail. The three telescopes are co-aligned for simultaneous UV imaging as well as spectroscopic and polarization measurements of the comet and other targets.

The Hopkins Ultraviolet Telescope will make brightness observations in the far-ultraviolet spectrum of very faint cosmic sources. These measurements will reveal the chemical composition of Halley, including the first attempts to measure helium abundance.

The Wisconsin Ultraviolet Spectropolarimeter will make simultaneous observations of the spectrum and polarization of UV light coming from stars. Unlike the Hopkins instrument, it will also investigate the distribution and destruction of dust grains in the comet's tail.

The Goddard Ultraviolet Imaging Telescope will produce images of very faint objects in the ultraviolet to study the overall cometary structure and to observe the effects of perihelion passage when the Sun's energy boils off material from the comet nucleus.

The first seven-day Astro mission, in early March 1986, will come at the same time as several probes intercept Halley. The last appearance of Halley was spectacular and widely viewed in 1910 when the comet appeared in the northern hemisphere's evening sky. The 1985/86 appearance however is not expected to be as spectacular because the comet will appear in the southern hemisphere before dawn and will be farther from the Earth than during its last return. Astro photography may be the best way to view Halley.

The least understood members of the Solar System, comets are thought to be primitive collections of ices and dust. Study could offer valuable insights into the nature of the primordial mixture from which our Solar System may have formed some 4500 million years ago.

Three scientists have been chosen to fly on the Astro missions, to fly in pairs on the three scheduled flights. They are: Dr. Samuel Durrance (Johns Hopkins University, specialises in ultraviolet astronomy); Dr. Kenneth Nordsieck (Univ. of Wisconsin-Madison, specialises in polarmetry) and Dr. Ronald Parise (Computer Sciences Corp., flight instrument development).

The three NASA mission specialists for the first flight will be Robert Parker, Jeff Hoffman (both astronomers) and David Leestma. The commander and pilot have yet to be chosen.

THE SPACE STATION

By Robert Sharples and James Hieatt

NASA has now decided on the 'power tower' space station design concept for Phase B advanced definition studies. This choice was one of three options, themselves selected from studies by eight major US aerospace contractors, among them TRW. The authors, TRW's Space Station Project Manager and Manager, Scientific Satellite Systems, describe that company's work as an illustration of how the original concepts were produced.

Introduction

The advent of the Space Shuttle makes space not only more accessible but provides science and industry with a viable means to transport men and materials to the high frontier. In fact, when NASA conceived the Shuttle some 15 years ago, the Orbiter itself was to be only part of a complete space system. It was originally intended to be a "space truck," linking Earth with projected orbiting space stations.

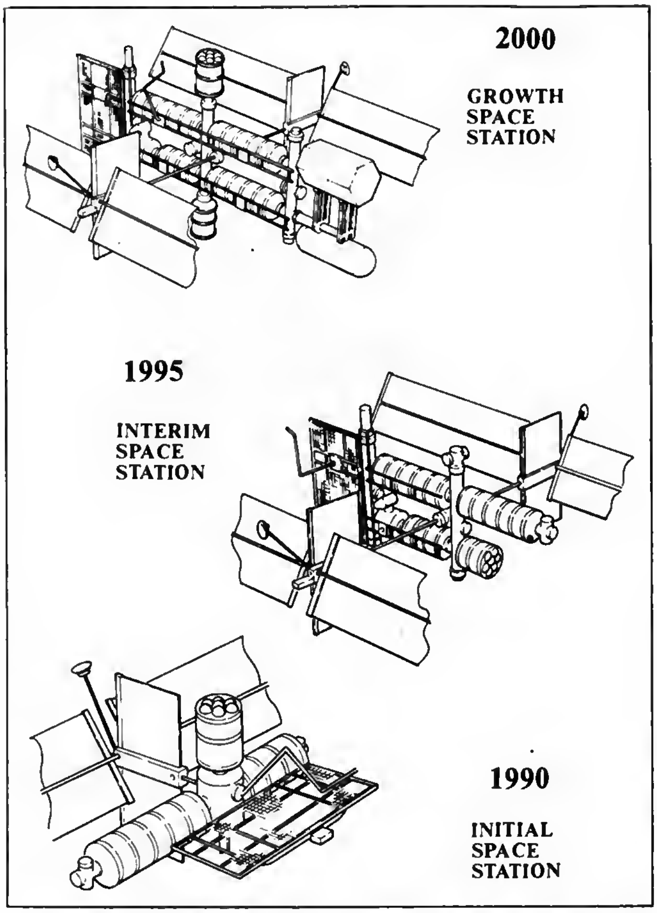
The concept of crewing manufacturing and laboratory facilities in orbit is not new. Skylab, launched in 1973, was essentially a manned space station. Although the US suspended its efforts in that arena, the Soviet Union did not. Salyut 6 stayed aloft for 58 months, hosting 30 cosmonauts and receiving 33 flights of manned and unmanned supply ships. Half of its orbital time was spent manned. Salyut 7, launched in April 1982, continues the programme.

Basic Space Station Principles

Since no one yet *knows* exactly what a US space station should look like, design concepts are fluid. There *is* one very important limitation, however. The architecture of any structure built in space is limited to segments that can be carried aboard the Shuttle. A building block approach, in which modular segments of the station are delivered over a period of time, is thus the most practical. Such a design would also provide flexibility and the capability to upgrade system elements as needed. It also allows for easy on-orbit replacement of failed parts, delivered, of course, by the Shuttle Orbiter.

Fabricating a structure in space has certain advantages. The launch environment, and not forces generated during operation in space, has always been a major design constraint on spacecraft systems. Eliminating the launch environment makes new design approaches possible. Standard interlocking pieces of equipment (modules) can be used to house the space station susbsystems. Much of the automatic deployment equipment needed today can be eliminated. Once an initial investment is made for a common cargo pallet to transport the modules to space, a "standard" vibration environment can be established for all designs. With the ability to test and assemble in space, virtually all system level ground testing can be eliminated. Thermal design trim, for instance, could be more easily accomplished on orbit.

Man will make a difference in space. Habitability modules will enable crews to stay onboard for months at a time. Scientific experiments and research can be closely monitored. Any equipment failures can be quickly analysed and corrected and human intellect can solve unforeseen problems that automated systems would be powerless to overcome.



The Space Station is intended to grow and be maintained on orbit, incorporating new technology as it becomes available. Three major configurations could evolve between 1990 and 2000. Each configuration would best accommodate users if augmented by free flying unmanned space platforms.

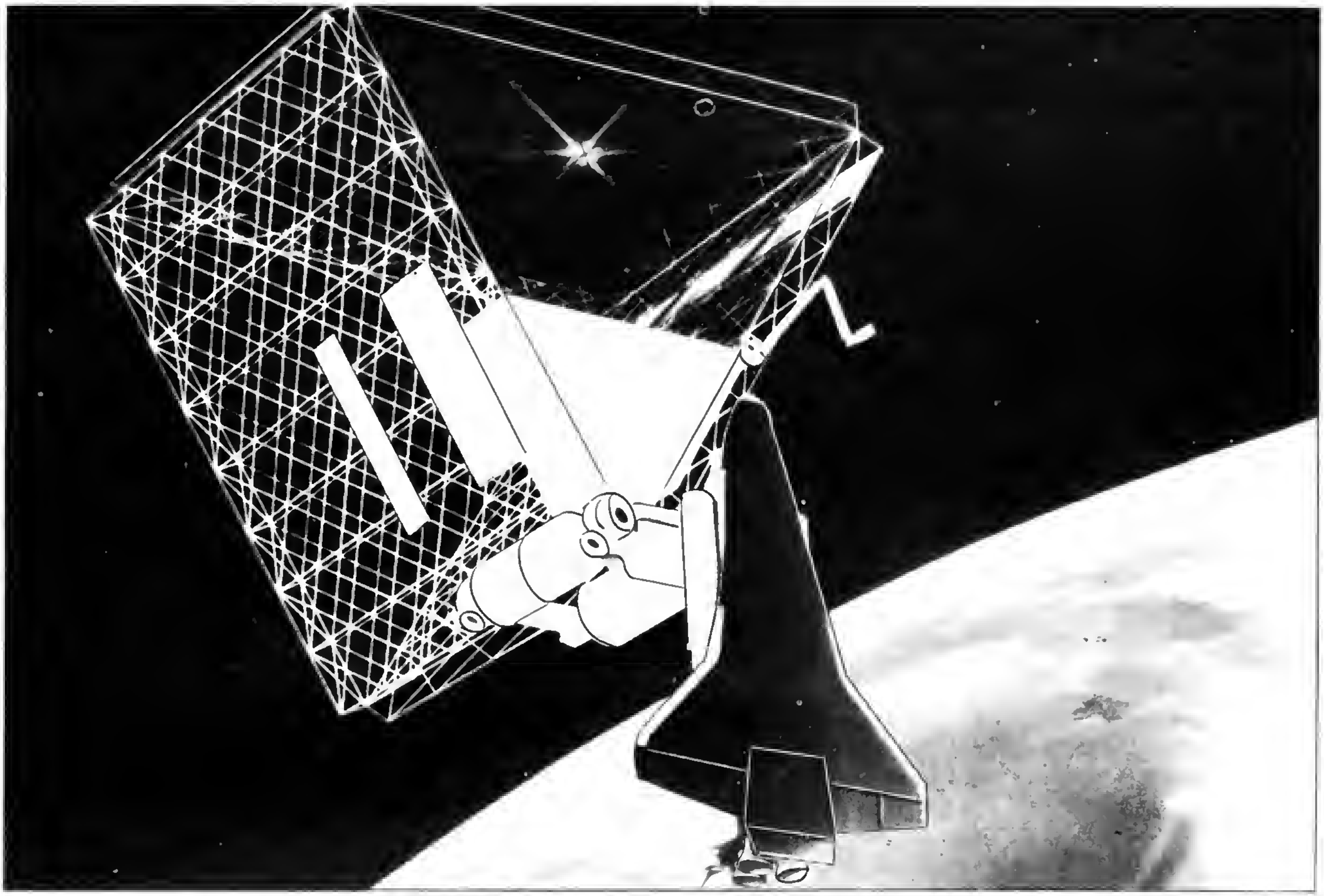
Why a Space Station?

Under a NASA contract, eight contractors were asked to identify and develop manned Space Station mission requirements, architecture, and financial, social and performance benefits. One of the first tasks was to determine just who would benefit from a permanent orbiting manned out-post and what those benefits would be. Establishing potential user needs enabled us to develop an appropriate mission model.

Science and Applications Needs
A panel of ten TRW scientists identified a number of science objectives by reviewing documents published by the Space Science Board of the National Academy of Sciences. Of 75 scientific missions studied, it was determined that 41 could benefit substantially from a Space Station. For several, including the Mars Surface Sample Return Mission and a similar excursion to an asteroid, the Space Station could serve as a staging point to perform final assembly and deployment. It could also provide capture and quarantine functions on the return trip.

A permanently manned laboratory for life science and material research aboard a Station could provide longer stay times than Spacelab's ten days. Long term experiments could be conducted independent of the STS. In addition, space platforms, in conjunction with Station servicing, could provide low cost accommodation for such multi-instrument facilities as the solar terrestrial observatory and the cosmic ray and X-ray observatories.

Commercial Communications User Needs
Of major importance to the commercial communications community is the opportunity, provided by the Space



One of the three designs studied by NASA is this triangular concept which would provide a rigid mounting for modules and experiments. *NASA*

Station, to assemble and test very large communications antennae before commitment to geostationary orbit. These antennae are difficult to test on Earth because of their light structural design. Early versions are being studied for deployment from the Shuttle but they will ultimately outgrow its limited capability.

A Station can offer lower launch costs to communications satellite users by "barging" (launching multiple satellites on the same vehicle) on reusable orbital transfer vehicles. Significant cost benefits accrue when communications satellite lifetimes can be lengthened by geostationary servicing.

Materials Processing

To determine projected needs for material processing activities aboard a Space Station, TRW held a two-day workshop attended by representatives from companies likely to use that capability. Participants believed then that it was too early to predict a market for Materials Processing in Space but concurred that a Space Station is desirable for research. MPS research is currently limited to short duration flights on Spacelab. With a manned laboratory permanently available, the need to relaunch Spacelab each time data are sought could be avoided. Once the research phase is over, materials production could be performed on a free flying facility tended by the Station.

Remote Sensing

With the help of two subcontractors, TRW also analysed the commercial market potential for remote sensing and a great deal of user enthusiasm was noted. A significant market exists for remote sensing data and, as the industry develops, the willingness of the private sector to invest in space resources will increase. We identified several areas that could benefit from remote sensing, among them: ocean wind/wave forecasting, sea ice forecasting, ocean monitoring for fisheries management, crop condition assessment and mineral resource discovery. The role of a manned Station in this user community would be mainly to provide maintenance and servicing of a remote sensing platform.

Cost Effective Transportation

During our study of proposed commercial and scientific missions we concluded that a permanent Space Station could significantly reduce space transportation costs. This emerged from several findings. First, average load factors of the Shuttle today fall around 65% of its maximum capacity because the cargo bay imposes more stringent limitations on spacecraft size than its lift capacity does on spacecraft weight. With the Space Station acting as a warehouse, spacecraft spare parts, fuel and replacement units can be flown aboard the Shuttle on a space available basis, increasing its load capacity to over 80%.

A second finding is that the Station can reduce the cost of deployment flights to geostationary orbit as well as permit the servicing/repair of GEO satellites. Repairs could be performed by a reusable orbital transfer vehicle, using the Space Station as a base of operations. These benefits, together, can amount to $10,000 million by the year 2000.

An Evolutionary Approach

We analysed a number of missions to determine the most appropriate design for requirements between 1990 and 2000. We found that free flying craft and observatories are most appropriate for multi-year missions with stringent pointing requirements, unique orbits and contamination sensitivity. Those with high resource require-

ments and frequent man-tending demands must operate in conjunction with a Station. Those man-intensive experiments requiring a pressurised environment with processes difficult to automate must be located within a laboratory attached to a Space Station.

To accommodate those four scenarios, we selected a manned Space Station that would evolve through three major configurations, beginning in 1990. The rationale for many of our architectural decisions was based on minimum programme cost and risk. A modest initial Space Station that has a high probability of being deployed on time, with well-controlled costs, was preferable to a programme that could encounter substantial cost overruns and schedule slips.

Space Station 1990

The initial Station conceived by TRW in 1983 could be deployed in 1991. It is modular in design to accommodate growth on orbit. Four Orbiter flights will be required to deliver the required elements to low Earth orbit (LEO). The first flight carries a resource module that supplies utilities and is designed to have high commonality with an unmanned space platform. Over the next several Orbiter flights, one habitability module, two airlock modules, a logistics module, remote manipulator system (RMS) and an assembly/servicing area are incorporated into the Space Station system. Four crew members arrive aboard flight three: a fifth crew member and the laboratory module occupy the whole of flight four.

At this point in the Station's evolution, solar arrays are sized to deliver 30 kW net power to the payloads and habitability module. The Space Station is 20 x 72 x 36 m in size and has a mass of 70,000 kg. It is capable of satellite servicing operations and can accommodate attached payloads *via* four berthing ports as well as manned laboratory activities within the infrastructure itself.

Although no new technologies are needed for the initial Space Station, there are several areas where progress would reduce cost and improve performance, including on-orbit cryogen transfer, Orbital Transfer Vehicle aerobraking, integrated hydrogen/oxygen systems, regenerable space suits, water and oxygen recovery systems, high efficiency solar arrays, regenerable fuel cells and safe nuclear power. The Space Station must be able to absorb these technologies as they become available. To allow for this, the "spinal cord" of data bus, electrical power distribution and fluid lines must be unchanging after its initial establishment, as should intermodule interfaces.

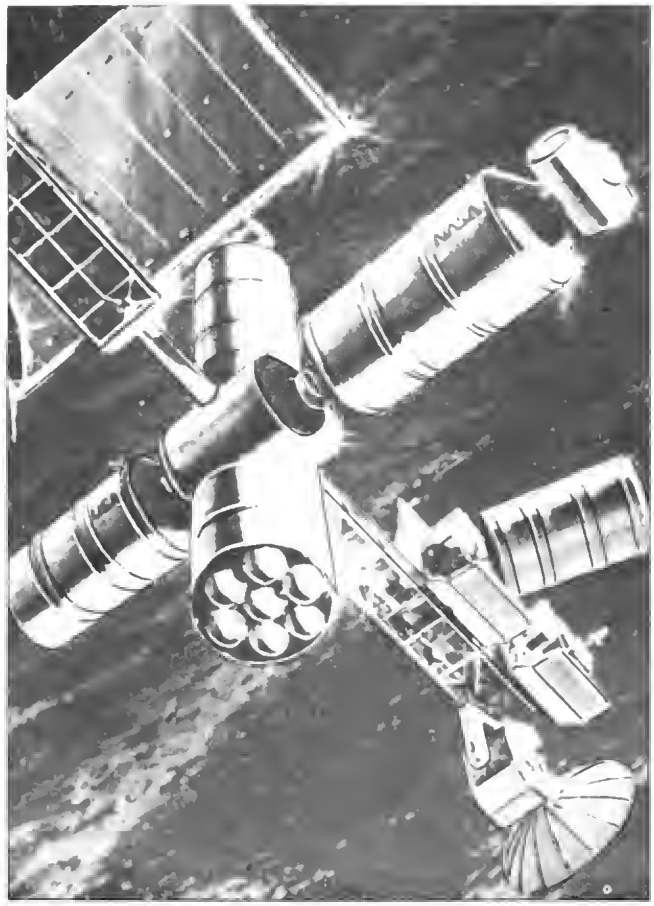
Space Station 1995

By 1995 the Space Station's power would be doubled through the addition of a second resource module. Another habitability module, two airlock modules and two interconnection tunnel modules are introduced. A rail and trolley system enables the Remote Manipulator System to move freely about the station. A command module provides clear vision of the rail and assembly areas.

Orbital Transfer Vehicles can at this point make routine visits to higher orbits for satellite servicing and repair. An eight-person crew would now be living and working aboard the structure which will have grown to 22 x 72 x 36 m and have a mass of some 100,000 kg.

Space Station 2000

By the end of the century, the proposed Station could support 10 to 12 crew members in five habitability modules. An additional tunnel module and logistics modules have increased the height of the station to 31 m. Berthing ports have increased to six to accommodate additional external payloads. A hangar shelter allows servicing of OTVs and other spacecraft and is itself



The central core of a TRW concept. *TRW*

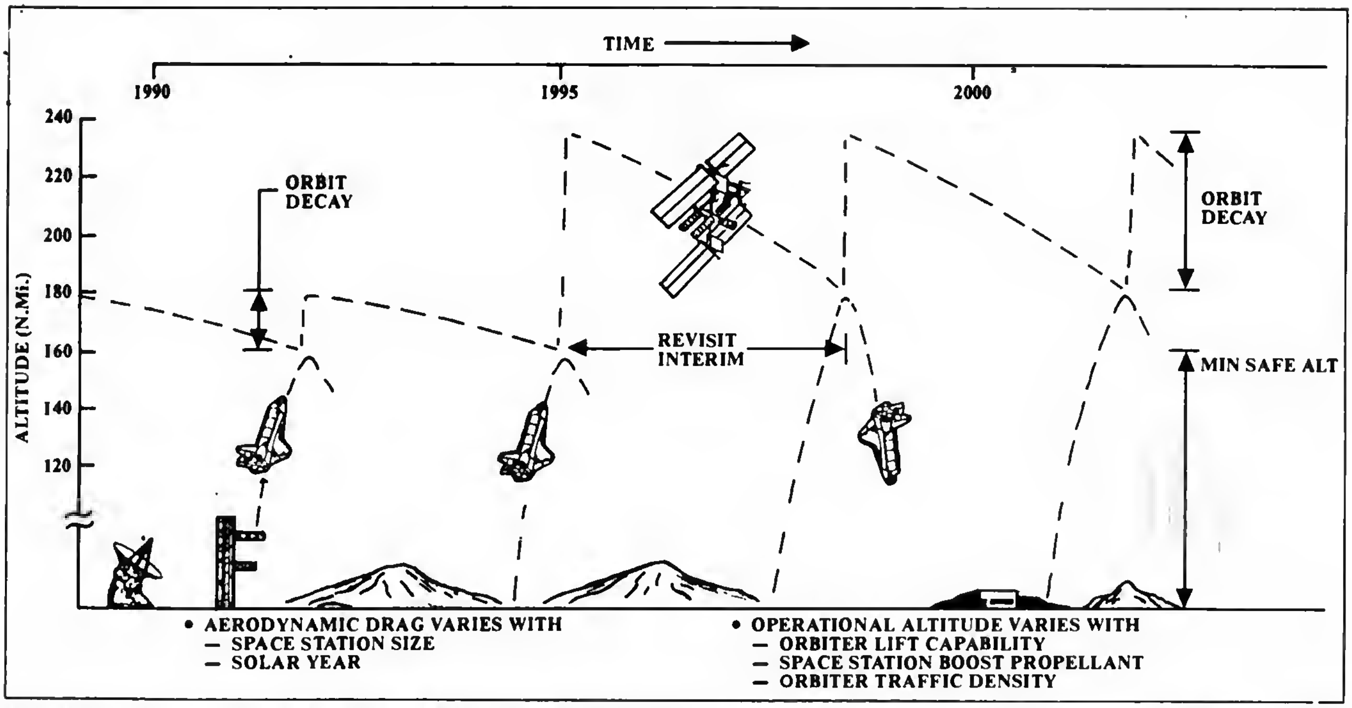
serviced by the rail system. A cryogen tank module allows for OTV refueling.

The preceding growth plan is based on a Space Station with an orbital inclination of 28.5°. We favour such an inclination because it satisfies the largest traffic volume. At this inclination, materials processing in space, life science and astrophysics missions can be accommodated at minimum cost, due to the lowest cost per pound low Earth orbit launch capability at that inclination. It is also well suited for staging GEO and planetary launches. A few missions would benefit from an inclination of 57°, but this inclination is largely a compromise between 28.5° and polar orbits, required primarily for Earth viewing. Our assessment is that polar orbit missions needed before year 2000 can be assisted by space platforms and freefliers serviced and tended by the Shuttle. We found no compelling need for a civilian polar station.

The construction of an orbiting Space Station will require a substantial investement. It can, however, be a profit-making venture for the US. The initial investment needed is approximately $8,000 million (1984 dollars). Additional funding of perhaps $10-12,000 million (1984) will be for two subsequent phases. This total investment will establish a net steady state benefit on the order of $2,000 million per year starting in 2000.

Space Station Requirements

The Space Station described here is an evolving modular system predicated on the idea of avoiding evolutionary dead ends. Since all modules depend on the Orbiter for transportation, assembly and supply, they must be compatible with its cargo size and weight restrictions. No modules need be discarded or returned to the ground once they are brought to space. The resource module, which supplies power and other subsystem



A boost/decay strategy was deemed most efficient by the TRW study, rather than maintaining the station at constant altitude. TRW

functions, shares much in common with the space platform to reduce costs without sacrificing capability.

System Safety Requirements
Crew safety is based on redundancy in all life sustaining equipment. The habitability module structure is intended to provide protection from micrometeorite particles of reasonable size. At least two airlocks, Orbiter berthing ports and egress paths per habitable area are included. It is assumed that an Orbiter rescue mission is available only with sufficient notice. This contingency is provided against by emergency safe haven supplies installed in all modules. An emergency reentry vehicle (ambulance) could provide quick return in medical emergencies.

Resupply Considerations
Resupply is based on the use of logistics modules transported by the Orbiter, then berthed to the Station where they remain until exchanged for fresh logistics modules from the next resupply flight. Logistics modules deliver all consumables, replacement units, fuel and supplies to the Station and return to Earth with rubbish and replaced, depleted or failed components.

Sufficient propellent will be stored to maintain the Space Station orbit for six months. However, normal 90-day supply revisits by Shuttle are assumed.

Altitude and Revisit Strategy
One of the most significant system trade-off studies made was to establish the optimum altitude for the Station. It was determined that a boost/decay strategy was most efficient, as compared to the maintenance of a constant altitude. Using this strategy, the Space Station would boost itself (following an Orbiter visit) to an altitude such that it would naturally decay to the rendezvous altitude by the time of the next revisit. The Orbiter's six to 12 revisits per year make its fuel efficiency requirements more important than the fuel needed to compensate for Space Station drag. It makes more sense for the Station to meet the Shuttle in a lower orbit and, as it turns out, the boost/decay strategy takes the least amount of propellant overall.

Payload Accommodation
Station configuration are crew size, power and internal operational volume. The selected configuration accommodates both external and internal payloads. External payloads may mount to any of three ports on each resource module. These payloads draw their power and cooling directly from the resource modules. Other external payloads may mount to ports scattered about the other station modules. These payloads must provide their own cooling. Internal payloads are accommodated inside the habitability modules, drawing cooling from the module they are in. Internal payload changes can be effected either by replacing portions that will pass through the ports or by designing the modules to open to their full diameter.

The Ground Segment
To reduce costs, it was assumed that all modules would be flight modules except one habitability module. For that representative module, an engineering model will be used for ground interface verification and training.

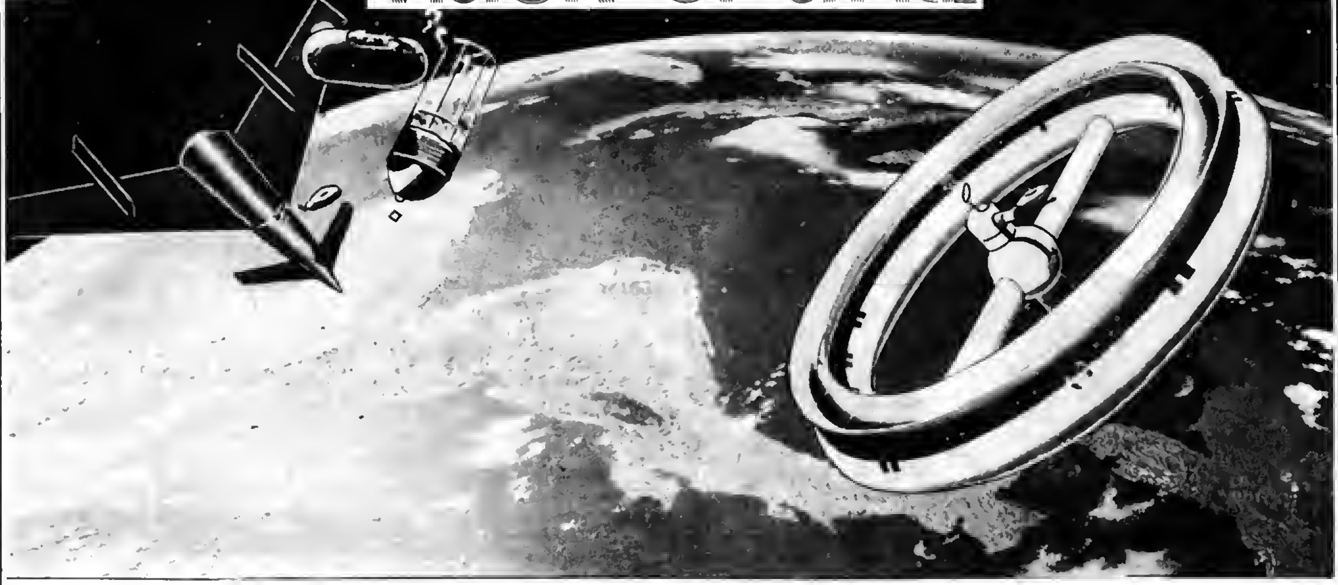
To reduce ground operation crew size, it is assumed that increasing space segment autonomy and ground segment automation will be necessary. Maximum use must be made of existing and planned NASA and Dept. of Defense facilities. A centralised control and communications capability is essential. All interfaces must be established at the beginning, allowing for growth and change independent of other facilities. Security provisions must also be made for the communications complex and interfaces at the outset. Payload operation control centers may be added as needed.

The Future

Our study has shown that a manned Space Station will generate many economic benefits. Most significant is the Station's ability to serve as a warehouse for parts, orbital replacement units and fuel, thereby increasing the Shuttle load factor. It would also open the door to zero gravity manufacturing and it might serve as a service and maintenance facility for future satellites.

An adapted version of an article that first appeared in

VISION OF SPACE



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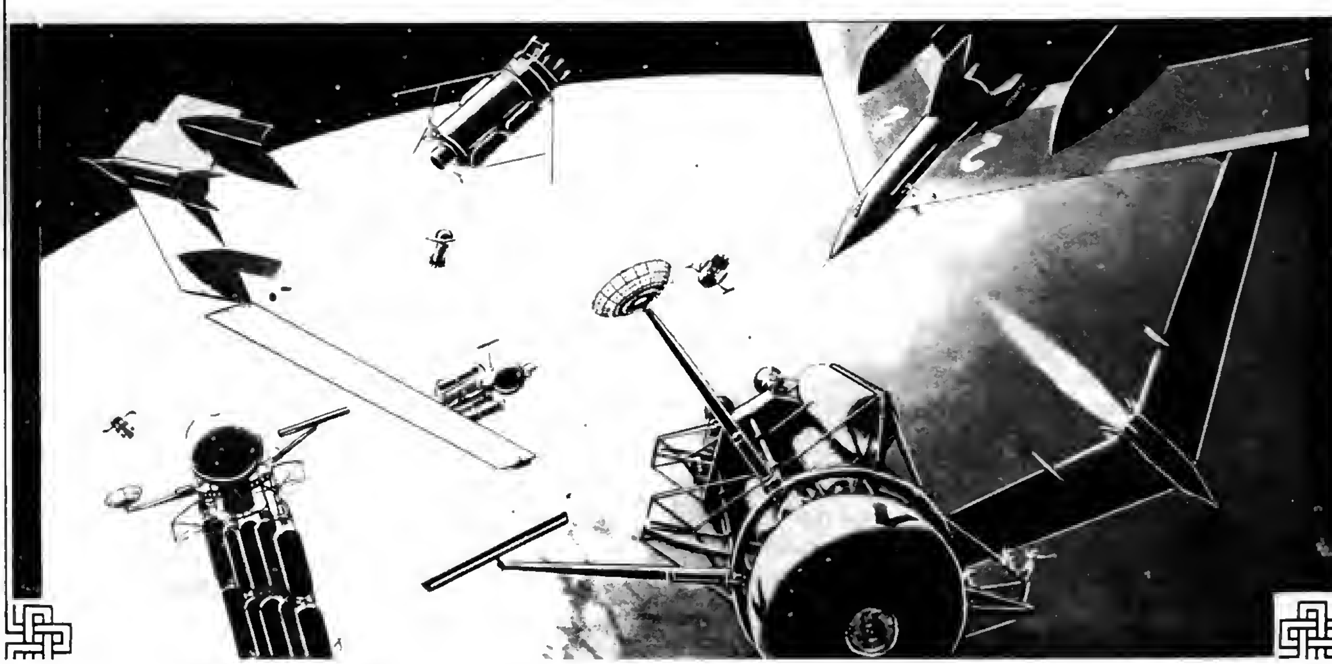


PLANETARY ATMOSPHERES

By Dr. Garry Hunt*

The recent advances in our understanding of planetary atmospheres has enabled their physical, chemical and dynamical properties to be compared quantitatively with terrestrial phenomena.

This article briefly reviews our current understanding of the atmospheres of the planets from Venus to Saturn and considers the challenging questions for future investigations.

Introduction

Knowledge of the atmospheres of planets provides fundamental information on their origin and evolution, thereby providing important constraints on theories of the observed distribution of material in the Solar System. This information will also enable a more quantitative investigation of whether these alien atmospheres could support our own or other forms of life. In addition, there are the vital studies in planetary meteorology. The variations in atmospheric conditions that constitute weather and climate are of major scientific, economic and political importance, particularly on the time scale of a human lifetime. But our understanding of these phenomena is far from complete for the Earth. We do not know whether man's activities might have any effect or whether external effects such as solar activity can modify the climate. Since terrestrial meteorology is complicated by the effects of oceans, continents, mountains and clouds, some perspective is emerging from studies of atmospheric phenomena on the other planets.

These planets, Earth, Mars, Venus, Jupiter, Saturn and the satellite Titan, have been examined at close range by spacecraft, in addition to the studies performed using Earth-based telescopic instruments and Earth-orbiting observatories. In this article, we will briefly look at the current understanding of these planetary atmospheres and the challenging problems of the next decade in this exciting and scientifically rewarding subject.

Venus

Venus is both sufficiently similar to the Earth yet sufficiently different to provide a fascinating climatological laboratory for investigation. The planet's slow rotation rate results in small Coriolis forces that might be predicted to cause less distinct latitudinal effects than those found on the Earth or in the atmospheres of the rapidly rotating giant planets such as Jupiter and Saturn.

We now find that the horizontal temperature gradients from equator to pole are very small owing to the efficiency of the atmospheric circulation in each hemisphere in transporting heat from the equator to the poles. In the equatorial region the rapid 4-day circulation, which translates to 100 ms^{-1} winds, predominates. We have found from Earth-based observations that there are fluctuations in each period of these equatorial cloud systems. Almost all the solar energy is absorbed in the neighbourhood of the cloud tops and provides the heating mechanism for the circulation. Its effects are conveyed to higher levels by transport mechanisms, where atmospheric wave phenomena are of major importance. Since these mechanisms do not act simultaneously the horizontal movement of the source of heat produces a tilt in the vertical pattern of convection which results in a net motion in the opposite direction to that of the Sun. It is therefore possible to create mean motions much faster than the heat source, and the magnification factor is largely determined by the vertical structure of the atmosphere.

A full-disc image of Venus recorded by Pioneer Venus Orbiter on 14 February 1979. *NASA*

In the upper atmosphere, where the radiative and dynamical time constants are less than a Venusian day, strong diurnal and seasonal effects have been seen. In the exosphere, at altitudes of ~200 km, the temperature can vary from 300 K on the dayside to only 100 K on the nightside.

Thermal tides are important too but, unlike the predominant wavenumber one response of the Earth, Venus exhibits a wavenumber two structure. Even more obscure features are the polar dipole and circumpolar collar that have been observed. They are virtually hidden from terrestrial observers since they occur at the high latitudes of 65-70° and 80-90° respectively, and appear as cold, nearly circular features. The collar is 5000 km in diameter while the dipole appears as two hot features, possibly holes in an otherwise ubiquitous cloud cover, about 1000 km either side of the pole and rotating about it with a period of 2.5 to 3 days. There is still a great deal we do not fully understand about the upper atmosphere circulation.

The clouds on Venus are composed primarily of sulphuric acid (H_2SO_4) products as a result of the photochemical actions taking place. They are opaque and absorb the majority of the incident solar radiation. The main upper cloud deck is embedded in the zonal circulation at altitudes of the greatest wind velocity and vertical wind shear. The clouds all appear to be of stratiform morphology and cloud particle growth is not strongly influenced by either the large-scale circulation of the latent heat released during condensation. There is little evidence yet for the existence of precipitation particles. The apparent observations of lightning in the deep lower atmosphere was quite expected. It may, however, be related to possible volcanic

* *Director, Centre for Remote Sensing, Imperial College of Science & Technology, London.*

activity indicated by the variation of the sulphur dioxide abudance by a factor of 50 in 1978 and has been decreasing in the past six years.

One question that is fully understood is the high Venus surface temperature of 737 K. The huge greenhouse effect caused by the build-up of atmospheric opacity through the higher solar flux incident on Venus has raised the high temperature. However, this effect cannot be achieved by the carbon dioxide alone. The small traces of water and sulphur dioxide are essential for the efficient greenhouse effect. Fortunately, the presence of the terrestrial oceans will prevent *our* atmospheric greenhouse effect running away in this manner.

Mars

The thin Martian carbon dioxide atmosphere responds rapidly to radiative and convective processes and to changes in the surface temperature. Since the characteristic radiative response time is only two days, compared with 100 days on Earth, the large scale atmospheric motions are strongly controlled by solar heating. However, the tenuous nature of the atmosphere results in inefficient heat transport by the winds so that large temperature contrasts exist. There are further complicating factors: the release of latent heat when carbon dioxide and water vapour condense to form the polar caps, the frequent dust storms that are created near perihelion affecting the thermal balance and atmospheric stability, and the huge topographic features in the form of deep basins and massive volcanoes.

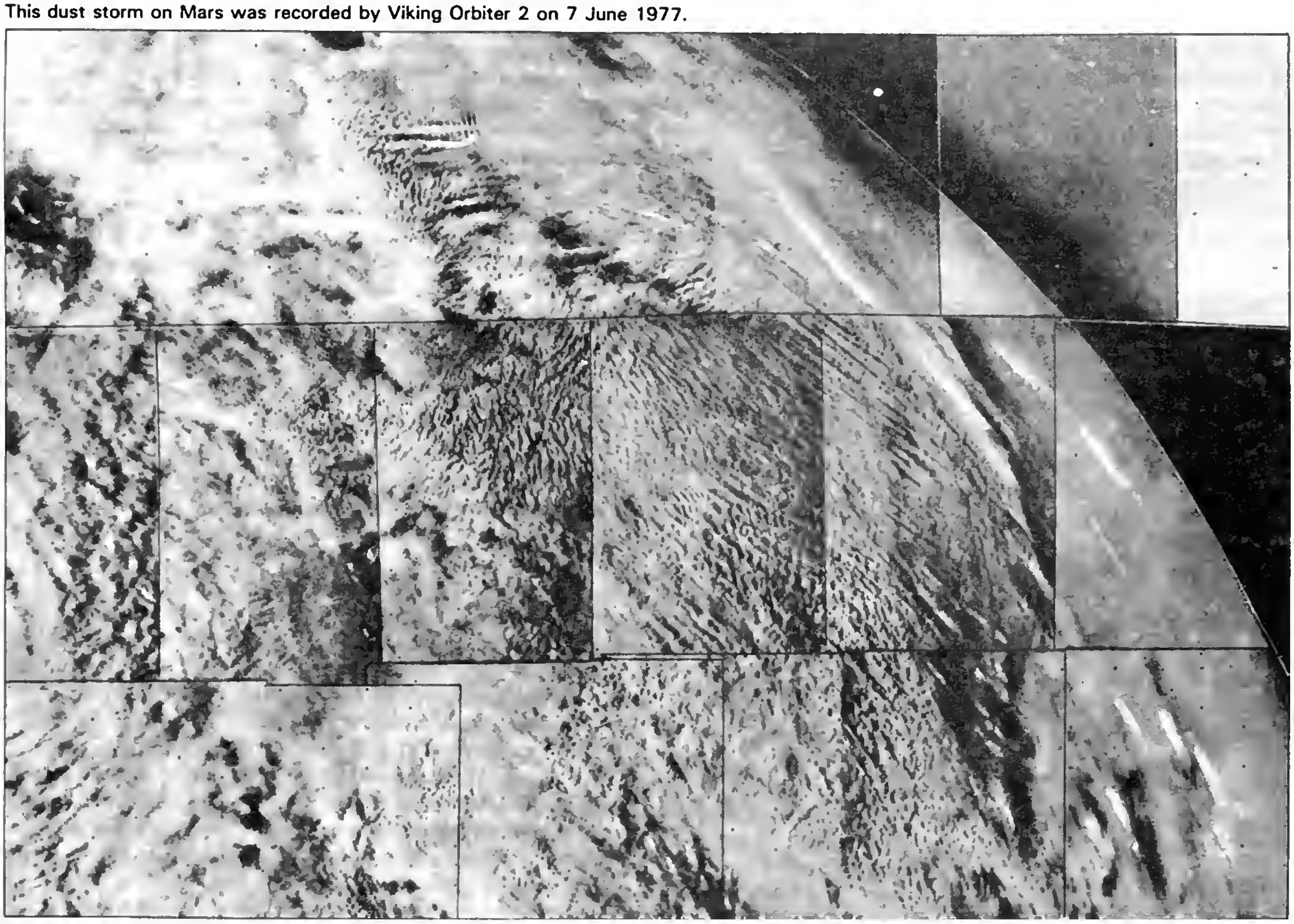
The Martian weather varies greatly with season and time of day. In winter a massive temperature difference between equator and pole produces brisk westerly winds and creates intense low pressure areas similar to terrestrial systems. In the southern hemisphere, Mars and Earth may differ greatly in their weather. The axial tilt of both allows, at the solstice, slightly more insolation in the summer polar regions than at the equator. Its relatively dense and cloudy atmosphere gives Earth a high reflectivity in the polar regions so that less solar radiation reaches the ground at the poles than the equator, even in mid-summer. For the transparent Martian atmosphere the reverse gradient may be exhibited. Light easterly winds will prevail and the usual planetary waves will be absent, so that there will be little in the way of weather. The dominant wind systems should then be tidal due to the atmosphere's rapid response to the changes in solar heating.

Since the Martian atmosphere is close to saturation, one would expect clouds to be plentiful. There is nothing resembling the dense, sharp-edged cumulus clouds we know on Earth. The Martian clouds are of four general types: convective clouds, wave clouds, orographic clouds and fogs. Indeed, one of the most surprising atmospheric observations made by the Viking spacecraft was early morning ground fogs in several low-lying areas, created when the ground frost is converted into vapour by the early morning Sun.

But water is not the only substance capable of forming clouds on Mars. In the winter polar regions and at high altitudes the temperatures can fall low enough for carbon dioxide to condense in a cloud layer. It is also possible that dry ice snow storms may occur in winter and help create the seasonal dry-ice polar caps. However, much of the dry ice in the caps is probably deposited when carbon dioxide gas comes in direct contact with the frigid Martian soil and condenses.

The interaction between the polar caps and the atmosphere has a unique effect upon the meteorology of Mars. About 20% of the carbon dioxide in the Martian atmos-

This dust storm on Mars was recorded by Viking Orbiter 2 on 7 June 1977.



phere is cycled between the cap and atmosphere each season, causing a corresponding variation in atmospheric pressure. The pressure variation is not local but is observed thoughout the atmosphere and has been measured at both the Viking landing sites.

One of the most dramatic aspects of Martian meteorology must be the dust storms, which frequently engulf the entire planet. In 1977 global storms occurred both before and during perihelion. In 1979, a global storm did not apparently occur, although local storms were detected. In 1981/2 the largest dust opacities ever were detected by the meteorological instruments. But without the orbiter observations we have no idea whether the storm developed into a global extent.

Jupiter and Saturn

Jupiter, Saturn, Uranus and Neptune are huge, rapidly rotating low density objects with optically reducing atmospheres. They contain more than 99% of the total planetary mass of the Solar System. The low density of these objects suggest that, like the stars, they are entirely composed of light elements (hydrogen, helium, etc), whereas silicates, iron and nickel mainly, constitute the cores of the inner planets. Since hydrogen and helium are thought to be the principal constituents of the solar nebulae, understanding the origin and evolution of these giant planets may hold important clues to the formation of the Solar System.

We will discuss only Jupiter, Saturn and, in the next section, Titan. These atmospheres have been investigated by the Voyager spacecraft, which have provided a quantum leap in our knowledge. Io, the Jovian satellite, also has a tenuous atmosphere, which results primarily from the intense interactions between the charged particle population of the magnetosphere in which the body is embedded, plus eddditional material injected from the active volcanoes over the entire surface of the satellite.

Both Jupiter and Saturn are composed primarily of hydrogen and helium. However, there are important differences between the planets. The hydrogen to helium ratio for Jupiter is approximately in the solar proportions. This is not the case for Saturn, which seems to have a helium depletion due to differences in the evolution of the internal structure compared with its neighbouring giant. The other primary constituents of the atmospheres are ammonia, methane, acetylene, ethane, phosphine and water vapour. Most of these constituents have been found in the cloud tops and in the stratospheric levels. Little information is currently known on the spatial distributions of these constituents, which through the active photochemistry may relate to the colourful appearance of these planets.

The visible appearance of both is a banded structure parallel to the equator of alternating light and dark bands of rapidly changing colours. For Jupiter, the Great Red Spot and the smaller scale features are prominent. On Saturn, detailed cloud morphologies are apparent in the Voyager processed images. In general, the white clouds are ammonia which are higher than the reddy, brown ammonia hydrosulphide clouds. On Saturn, the strong photometric properties make such a simple description less possible.

At first sight, the weather systems of these planets appear quite different from the familiar terrestrial meteorological phenomena. Furthermore, they are not driven solely by solar heating since each planet has a strong internal heat source emitting 1.7 and 1.8 times, respectively, the energy received from the Sun.

However, the analyses of the planetary momentum budgets suggest that, like the Earth, both Jupiter and Saturn drive their weather systems with energy extracted from the mean flow. Large scale features, such as the Great Red Spot, may have a long life, since they gain energy from the flow. In addition, the slow dissipation rate of radiation on Jupiter, which corresponds to 10 K/year, will allow features to last a long time compared with the terrestrial radiation rate of 1 K/day. The Great Red Spot is not, however, unique. It is simply the largest of a family of features which, on Jupiter, include the three white ovals and a train of other anticyclonic spots observed in the southern hemisphere. Saturn, too, seems to have its version of a red spot, but on a smaller scale. These spots do, of course, change in size. Currently the Great Red Spot is only 23000 km x 13500 km, which is half the length at the turn of the century. These giant meteorological features may have a finite life varying from years to decades to centuries. It is thought that the white ovals could disappear in the next decade but the lifetime of the Great Red Spot is unknown, although it is certainly more than 100 years.

The major unresolved meteorological issue is the depth of the observed motions. Deep models extending to the interior and shallow models that are a fraction of the planetary radius in depth can reproduce many of the observed features. Asymmetries in the flow on Jupiter created by the Great Red Spot are a problem for the deep models. However, a great deal more is still to be done to resolve these issues.

Titan

Although a satellite of Saturn, Titan possesses an atmosphere greater than that found on Earth. It is composed primarily of nitrogen with traces of methane, acetylene, ethane, methylacetylene, propane, diacetylene, carbon dioxide, carbon monoxide, hydrogen cyanide, cyanoacetylene and cyanogen. Many of these species are complex photochemical products which form layers of colourful aerosols in the atmosphere. The surface pressure is 1.6 atmospheres and the temperature 93 K, enough for a weak greenhouse effect to be present. The minor constituents are the result of an interesting chemistry that makes Titan appear like an Earth in deep freeeze.

The exact structure of the surface is unknown since it cannot yet be seen through the ubiquitous aerosol layers. However, it is possible that there could be an ocean of methane or ethane at the lower boundary.

There are no visible features in the cloud to track the atmospheric motions though the observed temperature gradients suggest cyclostrophic winds of 50 to 100 ms^{-1} at the 1 mb level. This would suggest a Venus-type meteorology of cloud motions faster than the planetary object itself.

The Future

In the immediate future we can look forward to the Voyager encounter with Uranus in January 1986 and Neptune in August 1989. Galileo, with its orbiter and probe, will provide a further dimension to the knowledge of Jupiter towards the end of the decade. The initial plans are now being made for a Mars Geochemical and Climate Orbiter and a Saturn orbit Titan probe mission named Cassini which could be a joint NASA/ESA probe. Little is known about the Russian future missions beyond their return to Venus in 1985/86 with the VEGA mission *en route* to Comet Halley.

We must not forget, however, the opportunities that will also arise with the Hubble Space Telescope and ground-based telescopes. We still have a great deal to learn about planetary atmospheres and many opportunities to increase our knowledge will occur in the next decade.

THE FIRST SPACE PRODUCT

By John Bird

A new era in space has begun - the first commercial product made in space will soon be available. The author recently visited BIS Fellow Dale Kornfeld, a NASA investigator on the Monodisperse Latex Reactor, to discover more on this intriguing development.

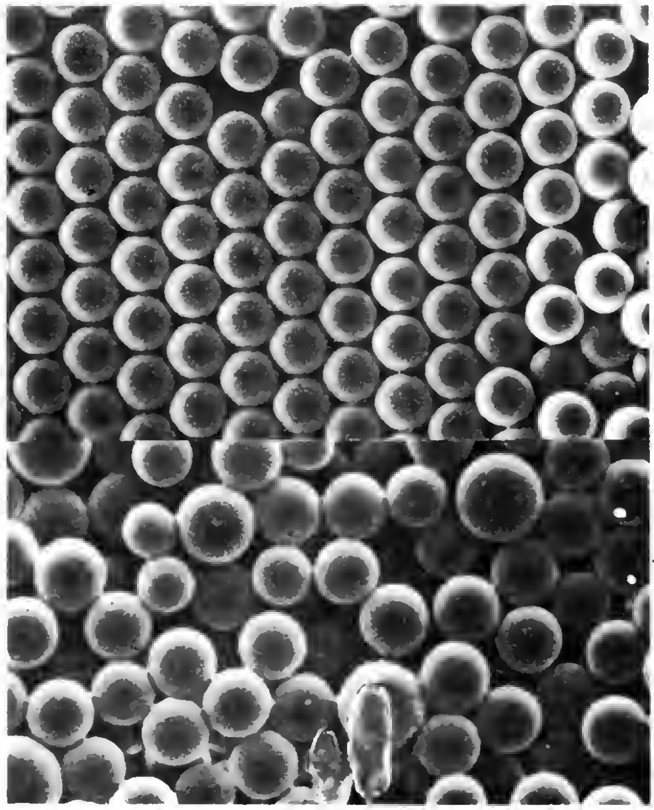
Introduction

The MLR has flown on Shuttle missions 3,4,5,6,7 and 41B but, even though many readers will have heard of it, what *is* the MLR? 'Latex' refers to a collection of small spheres, 'monodisperse' means they are of identical size and the reactor in this case refers to an oven where the chemical reactions occur. Hence, it is an oven in which small uniform spheres are produced. These spheres are so small that they cannot be seen individually by the naked eye but under an electron microscope they rather resemble billiard balls.

What on Earth are the possible applications of the latex? It can be used to calibrate microscopes because the microspheres have a diameter that is very accurately known - in effect, they can be used as miniature rulers. Another application is in using the spheres as tracers modified with radioactive elements or dyes for injection into humans to follow blood flow. The latex has already been injected into the arteries of animals.

Advantage of Weightlessness

Microspheres of uniform size can be manufactured on Earth but they are uniform only up to a maximum of 4 μm (1 $\mu m = 10^{-6}$m) in diameter. Larger spheres become non-uniform when made on the ground because gravity causes problems in the manufacturing process. In space, however, the spheres remain uniformly sized up to the largest made so far - 30 μm in diameter. The process starts with the small 2 μm spheres made on Earth. In orbit, the oven heats up the latex to cause a chemical reaction that increases the size of the spheres while maintaining uniformity.



Two samples of microspheres. Those produced during STS-7 (top) are remarkably uniform, with diameters of 17.8 μm. Those below were produced on the ground - note how they vary in size. *NASA*

Dale Kornfeld with the MLR reactor. *NASA*

Jack Lousma (left) and Dale Kornfeld prepare the MLR for the STS-3 flight in March 1982. *NASA*

Mission Sequence

As soon as the MLR is placed in the Orbiter before a mission the chemical reaction begins, *albeit* at a very slow rate. The experimenters, therefore, try to leave the installation as late as possible, making it the last to go aboard some 40 hours before lift-off.

The hardware consists of two packages, one containing four reaction chambers and the other the electronics. The 45 kg cylindrical housing is wheeled through the hatch along a support platform, jacked up by cargo technicians and bolted into place among the lockers in the Orbiter's mid-deck. The 22 kg electronics package is then lifted into place beside the cylindrical vessel. The operation is somewhat awkward because what is the forward wall in orbit is the ceiling when the Shuttle is on the pad. Dale Kornfeld, MLR co-investigator, is always on hand to check the installation. Work on launch preparations goes on 24 hours a day with three shifts and up to a maximum of seven technicians at a time working in the crew module. The astronauts often visit the Orbiter during these operations and Jack Lousma was on hand to help Dale for the STS-3 flight in March 1982.

During the mission, the crew activates the system with its four identical independent ovens that heat up to 75° C to produce the chemical reaction or 'polymerization.' Each reactor contains a different 'recipe' - for example, they might have different concentrations of chemicals. The initial, or seed, spheres grow larger during the 20 hours of operation, resulting in a product that consists of 75% water and 25% spheres by mass.

The spheres are made of polystyrene, a common plastic found in foam, with the repeated molecular unit consisting of two carbon molecules double bonded and a benzene ring attached to one of the carbons. Other materials may be used in the future.

Within a few hours of landing, the MLR is taken out of the Shuttle, boxed and shipped to the Marshall Space Flight Center in Alabama in a NASA aircraft. The water and its latex are then cleaned by the removal of chemicals such as initiators, inhibitors and emulsifiers. The last is a soap-like substance that prevents the spheres from sticking together during their formation. Some of the spheres are launched again as seeds for bigger spheres. The largest produced to date are 30 μm and 100 μm versions have been ordered but the maximum diameter possible is unknown.

First Commercial Product

MLR microspheres will soon be the first space product to be sold commercially, marking the beginning of space industrialisation. The principal investigator, John Vanderhoff of Lehigh University in Pennsylvania, has formed the Particle Technology, Inc. company to market small phials containing 99.5% water and 0.5% microspheres at $400. The latex has to be kept in solution otherwise the spheres would stick together and be permanently damaged. The cost works out at $20,000 per gram of solid latex. As of late June, eight customers had already placed orders. NASA presented a 15 g sample of 10 μm spheres to the US National Bureau of Standards in July to certify them as 'standard reference material' suitable for sale early in 1985.

The current MLR is now almost totally automated but it would be possible to build a new version that would allow the operator to make repairs, examine specimens with a microscope, change conditions in the reactor and optimise the process during flight. A large-scale version might be flown by industry. Out of small acorns, great oaks grow...

JBIS

The October issue of *JBIS* is devoted to "Solar System Exploration," with the following papers:

1. 'Questions for the Geologic Exploration of Venus' by R.S. Saunders;
2. 'The Venus Radar Mapper Mission' by E. Cutting *et al;*
3. 'Pioneer to Venus: the Multiprobe and Orbiter Missions' by R.A. Craig *et al;*
4. 'Exploring Beyond the Planets: The Pioneer 10 and 11 Missions' by P. Dyal and R.O. Fimmel.

The September issue of *JBIS* is devoted to "Interstellar Studies," with the following papers:

1. 'An Approach to the Modelling of Matter-Antimatter Propulsion Systems' by G. Vulpetti;
2. 'The Number of Inhabited Planets in the Galaxy' by T.B. Tang;
3. 'Artificial Intelligence as an Evolutionary Stage of Human Mind' by P. Molik;
4. 'Computer Simulation of Cultural Drift' by W.S. Brainbridge.

The November *JBIS* is also devoted to "Interstellar Studies." Copies of each *JBIS* are available from the Society at a cost of £2 ($4) post free.

1985 SUBSCRIPTION FEES

There is good news for all members: fees for 1985 will remain unchanged from 1984 in spite of rising costs.

Direct Debit Scheme

Our old Bankers Order System has been phased out. Direct Debit slips to become effective from January 1985 are now available from the Executive Secretary. They *must* be returned before 15 Nov. or else they will not come into operation until 1986 and a separate remittance for 1985 will have to be made.

Amounts payable for the calendar year January-December 1985 are as follows:

RATES

Members	Sterling	US Dollars
Under the age of 18 years	£16.00	$26.00
Between 18 and 20	£18.00	$30.00
21 years of age and over	£21.00	$36.00
Fellows	£23.00	$40.00

Age Allowance

A reduction of £4.00 ($6.00) is allowed to members of every grade over the age of 65 years on 1 January 1985.

JBIS and *Space Education*

The additional subscription payable for *JBIS*, where required as well as *Spaceflight*, is £20.00 ($34.00). For *Space Education*, it is £4.00 ($6.00).

Methods of Payment

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(a) Please pay in sterling with a cheque which shows a UK address, where it can be paid.

(b) Cheques drawn in sterling payable at a bank in Europe must include £2.00 to defray charges and collection costs. Eurocheques have no charges *only* if the account number is written on the back.

(c) Banks which remit directly to the Society must be told to see that the sum is transmitted *free of deductions*.

(d) Remittances from Europe are best made by GIRO. Our GIRO account number is 53 330 4008.

USA and CANADA

(a) US dollar cheques can be drawn on a Bank which gives an address in the United States or in the UK. US dollar cheques drawn elsewhere need to be increased by $8.00 to cover collection charges.

(b) US dollar notes are accepted.

(c) US or Canadian money orders can only be accepted if *expressed in Sterling*. Internal money orders from these countries i.e. those expressed payable in dollars will be returned as they cannot be cashed in the UK.

(d) Canadian bank remittances may easily be made in sterling drawn on their UK agents. If payment is made in Canadian dollars the current exchange rate may be used, plus the addition of 8 Canadian dollars to cover exchange and collection charges.

FROM THE SECRETARY'S DESK

Extending our Base

Time has flown by in the five years since we moved into our new HQ. The move led to a great upsurge in our Society, revitalising many of its activities. Our magazines have been greatly improved and extended, we are fully established in our Conference Room, our meetings programme has been re-vamped with an emphasis on major events, with Space '84 as just one forthcoming example - and, besides all this, we have created a very valuable specialised space Library from practically nothing.

The Planning Permission which arrived from the Local Council recently paves the way for further developments. One of the most important of these would be to extend our building and enlarge the capacities both of our Conference Room and of our Library.

Our present Conference Room holds around 50. We could make it bigger, or provide an extra area for exhibition or display purposes, or even to use it for refreshments when we hold all-day meetings.

Our Library gets bigger daily and, before long, will need extra room. Extension here would prove invaluable, not only by providing space for additional bookstacks but also in creating space for administration, something we badly lack.

We still have more hurdles to cross before the possibility of an extension becomes real, notably tying-up the agreement with owners of the adjoining property, but all such matters are well under way.

Astronautics Medallions

As part of our search for astronomical and astronautical medallions I had occasion to refer to *Commemorative Medals* by J.S. Whiting (David & Charles) 1972.

Listed as UK producers of such items were the following:

Apollo 8 coins from Memorial Coins & Medallions Ltd.

Astronautics coins from Prestons Ltd.

Apollo 11 silver-plated medals put out by, of all people, Boots the Chemist, produced for them by Infoplan in crown-size.

Have members ever seen any of these?

Imagine my surprise to see, also listed in the same book, the three gold medals presented by our Society to each of the Apollo 11 astronauts.

Fame appears in the most unexpected quarters!

Museum Musings

Whether the Society will ever possess a small Museum lies in the lap of the Gods, though I feel sure members visiting HQ would be more than delighted to see such things. Currently our two display cases are full and, hopefully, more items will be collected as the years go by. A Treasury of items relating to the Society itself, its space activities and the activities of its members is surely a "must."

It would also be nice if we could infill with a collection of items showing the development of interest in space - technical, scientific and popular (even if misguided). It would include items on astronomy, early rocket experiments, basic theoretical works and similar items and embrace books, artefacts and a wide range of documents.

Much of the older material is probably rare and more than our members possess or could donate to us, so a source of funding is indicated - particularly if we have to purchase such items.

The problem of old books is particularly acute for their illustrations, especially of celestial maps, are usually torn out and sold separately for prices of £100 or so upwards. Dealers attend auctions to buy up every book which can be thus de-gutted, so these volumes are lost for posterity and can only be retrieved, at some future date, if a facsimile of a copy lucky enough to survive appears. Our heritage of old books is rapidly being destroyed so the need for our Society to get its collection together at the earliest possible date is quite urgent.

Personal Records

I really do urge members with space-related books, papers and other items to make sure that these will be preserved for posterity by the Society.

The alternative can be very sad. If the interest or value is not immediately apparent, they can be sold off to a second-hand dealer or simply thrown away. Many good collections have been broken up already and their association with the Society lost.

The Council has already requested member-authors of space books to sign, date and present a copy to the Society for these, too, are basically a form of preserving personal records.

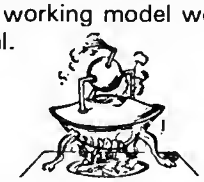
Members wanting material to go to the Society upon their deaths could include details in their Wills. Even a Letter of Intent might do, if left with one's private papers, though the Society - then - has no right to insist that its terms are actually carried out.

This shows how necessary it is to make sure that material is placed in the care of the Society for safekeeping at the earliest possible date.

Hero's welcome

The Library Committee is seeking a member with the necessary expertise and goodwill to make and donate to the Society a model of the "aeolopile" of Hero of Alexandria, (c 1st Century B.C.) widely regarded as the first demonstration of a reaction engine.

The model we seek needs to be quite small i.e. not more than 10" across: a working model would be prefereable though not essential.

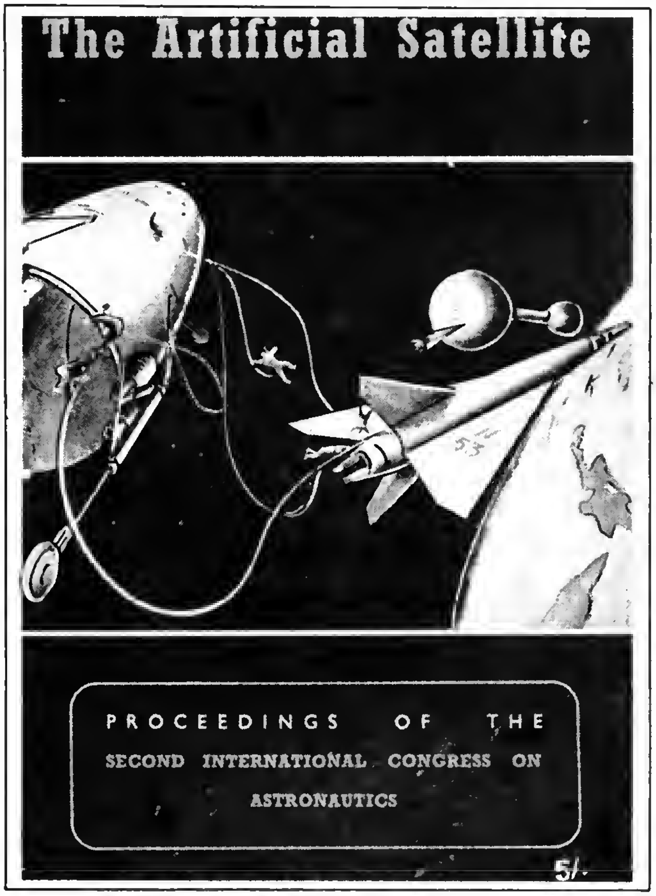


The aim is to include it with those already displayed on the tops of our Library shelves (we have space for another 20!) and so enhance the Library's "space atmosphere."

Bookwise

The Society's first publication was a booklet called

"The Artificial Satellite" edited by myself and based on important papers presented at the 1951 Congress. 1,000 copies were printed. Some were sold but the object was not so much to sell copies as to send them, with a covering letter, to everyone - particularly in industry - likely to have a potential interest in space developments. The idea was to tell them about the emerging space potential and to outline some idea of the opportunities involved. Over 500 copies were sent to US addresses alone.



Over the years the Society has produced, supported or initiated a great range of space books under the imprints of various publishers, some reprinting Society material, others not.

Only comparatively recently, following a near-collapse of sales of space books by commercial publishers, has the Society re-entered the field directly and produced its own volumes. The facsimile reproduction of the Bayer Atlas, probably once used by James Bradley, is the fourth to appear.

First Day Covers

Not many friends (or even enemies) now possess any first day space covers. Since the Library Committee decided to set up a Special Collection of these a clean sweep has been made of practically everyone in sight. True, three stalwart volunteers came forward - Lester Winick with American covers, Rex Hall with Soviet covers and Lilian Valentin with ESA covers, but the formidable nature of the task becomes apparent when one reflects that a pre-war set of rocket-mail covers is currently on sale for about £20,000 and a post-war set for £10,000. The gap between this and the paltry sum we can rustle up is positively gaping.

Nevertheless, wonderful support and our own Trojan efforts have paid off, with the result that the Society's collection has grown from zero 18 months ago to nearly 400 now.

We still have a few bad gaps. Particularly lacking are pre-war European and Australian rocket-mail covers, and we barely reach a dozen with astronomical covers. Nonetheless, we are well satisfied with things to date and will continue to see that our basic collection grows and, in good time, be something our Society will be proud to have.

Asserting our Identity

As members will have noted from our Editorials the Society is undertaking a progressive role both to promote space in the UK and to assert its own identity as the main UK organisation devoted wholly to space. This is not just a change in emphasis but the logical outcome of a building-up process which has been taking place within the Society for several years now, beginning with the establishment of its new HQ, the creation of a fine Library and the acquisition - as opportunity presented itself - of pictures and similar items appropriate to a Learned Society. A good deal of work has also gone into promoting the Society's image and activities as well as its interests.

Our latest publication is a leaflet describing the Society purely in terms of "as others see us," with further reinforcement in the shape of a booklet on the Society's interests in the political and economic scenes.

Members who can use our promotional material can write or telephone the Society for copies at any time. It will be sent either singly or in batches - to the member's address or to persons nominated.

Our objective is not only to strengthen the Society but to make it better able to tackle the many new tasks and seize the many new opportunities now confronting us.

Wants

The success of the Appeal for pictures of comets and meteors in our last issue seems to underline the fact that not only are members genuinely interested to know about our problems but will help out, too. This fact was not lost upon the Library Committee, ever vigilant to further the Society's interests, a task which they perform with merit though with much wailing over every item which gets away.

A particularly loud wail greeted the news a little while ago that some interesting correspondence by Sir William Congreve had been sold elsewhere. It is probably unlikely that any members of the Society possess alternative items from Sir William which might placate them (incidentally, were early matches called Congreves?) but they might be satisfied with something else, e.g. correspondence of early space pioneers or leading astronomers.

I offer this to anyone wishing to support a good cause.

Patronage

Most members will have noticed that a portrait of Sir Isaac Newton, together with a specimen of his Newtonian telescope, appears on the current £1 note.

He actually achieved currency fame much earlier than this for he appears on tradesman's token issued in Middlesex in 1793, a specimen of which we now have on display in the Library.

The work of Sir Isaac is particularly important to members of the Society as his theory of gravitation not only laid the basis for present-day space developments but, as pointed out by our President some years ago, he was fully aware of escape velocity and the theoretical possibility of reaching other worlds. With so much to his credit, Sir Isaac probably has as good a claim to be the Society's Patron as anyone.

DESIDERATA

The Library Committee is seeking the following books for the Society's Library. Any member who can help is urged to contact the Executive Secretary.

A.L. Lowell	Biography of Percival Lowell	Macmillan Co., 1935
F. Bailey	An account of the Revd. J. Flamsteed	Dawsons, 1966
A. & P. Bear	Kepler - 400 years	Pergamon, 1975
H.M. David	Wernher von Braun	Putnam & Sons, 1967
J.L.E. Dreyer	Tycho Brahe	Dover, 1963
M. 'Espinasse	Robert Hooke	Univ. of Calif., 1956
E.G. Forbes	The Greaham Lectures of Jon Flamsteed	Mansell Pub. Ltd, 1975
J. Kepler	Somnium (Trans)	Univ. of Wisconsin Press, 1967
F.E. Manuel	Portrait of Isaac Newton	Harvard Univ. Press, 1968
L.T. More	Isaac Newton	Dover, 1962
C.A. Ronan	Astronomers Royal	Doubleday, 1969
H.J. Steffens	The Devpt. of Newtonian Optics in England 1977	Neale Wats on Academic
H.B. Walters	Wernher von Braun - Rocket Engineer	Macmillan, 1964
R.S. Westman	The Copernican Achievement	Univ. of Calif., 1975
I.B. Cohen	Newton's Theory of the Moon's Motion	Academic Pubs., 1975
T von Oppolzer	Canon of Eclipses	Dover, 1962
H. Woolf	The Transits of Venus	Princeton Univ. Press (or Arno Press), 1959
H.S.F. Cooper	Moonrocks	Dial, NY., 1970
A.J. Meadows	Early Solar Physics	Pergamon, 1970
J.P. Nichols	The Planet Neptune	John Johnstone
Y Ohman, ed.	Mass Motions in Solar Flares and Related Phenomena	MacMillan, 1968
H. Zirin	The Solar Atmosphere	Blaisdell Pub. Co., 1966
W. Ley	Visitors from Afar - The Comet	McGraw Hill, 1969
J. Mascart	Le Comete de Halley.	Gauthier-Villars, 1911
C.P. Olivier	Comets	Williams & Wilkins, 1930
P.L. Brown	Comets - Meteorites	Taplinger, NY, 1974
A.H. Delsemme	Comets, Asteroids, Meteorites	Univ. of Toledo Press, 1977
C.D. Hellman	The Comet of 1577 - its Place in the History of Astronomy	AMS Press (or Columbia Univ. Press), 1944
G.P. Kuiper & E. Romemer	Comets: Scientific Data & Missions	Univ of Arizona Press, 1972
V.F. Buchwald	Handbook of Iron Meteorites	Univ. of Calif. Press, 1975
S. Drake & C.D. O'Malley	The Controversy of the Comet of 1618	Univ. of Penn Press, 1960
E.L. Krinov	Giant Meteorites	Pergamon Press, 1966
B. Mason	Meteorites	J. Wiley, NY 1962
H.H. Nininger	Arizona's Meteorite Crater.	World Press, Denver, 1956
R.S. Richardson	Getting Acquainted with Comets	McGraw-Hill, 1967
H. Jeffers & W. Van de Bos	Index Catalogue of Visual Double Stars	Lick Observatory, 1963
J.W. Sulentic & W.G. Tifft	Revised New General Catalogue of Nonstellar Astronomical Objects	Univ. of Arizona, 1973
E.W. Downs, Ed.	The US Air Force in Space	Praeger, 1966
A. McIntyre	Summary of AFCRL Rocket & Satellite Experiments (1946-1966)	AF Cambridge Research Laboratories, 1966
	Space Handbook. Maxwell Air Force Base	Air University Revised annually
E. Abel	The Missile Crisis	Lippincott, 1966
J. Baar & W.E. Howard	Combat Missilemen	Harcourt, 1961
E. Bergaust	Rockets of the Armed Forces	Putnam, 1966
E.M. Bottome	The Missile Gap	Fairleigh Dickinson Univ., 1971
B. Collier	The Battle of the V-Weapons	Morrow, 1965
W. Dornberger	Nuclear Flight: The United States Air Force Programs for Atomic Jets, Missiles & Rockets	Duell, 1960
W. Dornberger	The United States Air Force Report on the Ballistic Missile: Its Technology, Logistics & Strategy	Duell, 1960
C. Gurney, Ed.	Rocket & Missile Technology	Watts, 1964
M. Hunter	The Missilemen	Doubleday, 1960
R. Neal	Ace in the Hole: The Story of the Minuteman Missile	Doubleday, 1962
S. Ulanoff	Illustrated Guide to US Missiles & Rockets	Doubleday, 1962
USAF Missile Develop. Center	History of Research in Space Biology & Biodynamics	Holloman AFB, 1959
S.W. Smith	A Handbook of Astronautics	Univ. of London Press, 1967
J. McGovern	Crossbow and Overcast	Morrow & Co, 1964
B. Kit & D.S. Evered	Rocket Propellant Handbook	MacMillan, 1964
K.F. Gantz, Ed.	Men in Space: The United States Air Force Program for Developing the Spacecraft Crew	Duell, 1959
J.J. Haggerty	First of the Spacemen	Duell, 1960
R. Hirsch & J.J. Trento	The National Aeronautics and Space Administration	Praeger, 1973
M.M. Link	Space Medicine in Project Mercury	
F. Golden	Colonies in Space: The Next Giant Step	Harcourt Brace & Javanovich, 1977

SATELLITE DIGEST-177

Robert D. Christy
Continued from the September/October issue

A monthly listing of satellite and spacecraft launches compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

COSMOS 1552 1984-45A, 14971

Launched: 1400, 14 May 1984 from Tyuratam by A-2.
Spacecraft data: Possibly based on the Vostok manned spacecraft with spherical re-entry module, instrument unit and a cylindrical, supplementary payload at one end. Length about 6 m, diameter 2.4 m (max) and mass around 6000 kg.
Mission: Military photo-reconnaissance.
Orbit: 182 x 322 km, 89.54 min, 64.93°.

COSMOS 1553 1984-46A, 14973

Launched: 1444, 17 May 1984 from Plesetsk by C-1.
Spacecraft data: Cylindrical body with domed ends, enclosed in drum-shaped solar array with length and diameter both about 2 m, and mass around 700 kg.
Mission: Navigation satellite.
Orbit: 963 x 1008 km, 104.87 min, 82.93°

COSMOS 1554-56 1984-47A-C, 14977-9

Launched: 1511, 19 May 1984 from Tyuratam by D-1-E.
Spacecraft data: Possibly similar to Cosmos 1553.
Mission: Triple launch of satellites in the GLONASS navigation satellite programme.
Orbit: 19131 x 19159 km, 676.33 min, 64.81°.

COSMOS 1557 1984-48A, 14982

Launched: 0830, 22 May 1984 from Plesetsk by A-2.
Spacecraft data: Similar to Cosmos 1552.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package. Recovered after 13 days.
Orbit: 211 x 247 km, 89.15 min, 82.33°.

SPACENET 1 1984-49A, 14985

Launched: 0130, 23 May 1984 from Kourou by Ariane 1.
Spacecraft data: Box-shaped body with two solar panels, mass 705 kg in orbit.
Mission: Communications satellite.
Orbit: Geosynchronous above 120° west longitude.

COSMOS 1558 1984-50A, 14993

Launched: 1130, 25 May 1984 from Plesetsk by A-2.
Spacecraft data: As Cosmos 1552.
Mission: Military photo-reconnaissance, recovered or re-entered after 44 days.
Orbit: 168 x 294 km, 89.13 min, 67.16°.

PROGRESS 22 1984-51A, 14996

Launched: 1413*, 28 May 1984 from Tyuratam by A-2.
Spacecraft data: Near-spherical supplies compartment, conical fuel tank section and cylindrical instrument unit. Length approx. 7.5 m, diameter 2.2 m and mass around 7000 kg.
Mission: Delivery of fuel, scientific equipment and maintenance materials to Salyut 7. Progress docked with Salyut's rear port at 1547, 30 May 1984.
Orbit: Initially 188 x 244 km, 88.80 min, 51.63°, and then by way of a 202 x 295 km, 89.42 min transfer orbit to a docking with Salyut at 334 x 358 km, 91.39 min, 51.61°.

COSMOS 1559-66 1984-52A-H, 14998-15005

Launched: 2153, 28 May 1984 from Plesetsk by C-1.
Spacecraft data: Spheroid in shape with length 1 m and diameter 0.8 m and mass around 40 kg each.
Mission: Military communications.
Orbit: 1385 x 1488 km, 114.63 min, 73.97° (lowest) to 1470 x 1511 km, 115.82 min, 74.01° (highest).

COSMOS 1567 1984-53A, 15009

Launched: 1845, 30 May 1984 from Tyuratam by A-2.
Spacecraft data: Not available.
Mission: Electronic reconnaissance over ocean areas.
Orbit: 432 x 442 km, 93.32 min, 65.03°, maintained by low thrust engine.

COSMOS 1568 1984-54A, 15011

Launched: 1350, 1 Jun 1984 from Plesetsk by A-2.
Spacecraft data: Similar to Cosmos 1552.
Mission: Military photo-reconnaissance, recovered after 13 days.
Orbit: 356 x 414 km, 92.30 min, 72.83°.

COSMOS 1569 1984-55A, 15027

Launched: 1534, 6 Jun 1984 from Plesetsk by A-2-e.
Spacecraft data: Possibly similar to the Molniya satellites.
Mission: Missile early warning satellite.
Orbit: Initially 588 x 39834 km, 710.03 min, 62.90°, then raised to 587 x 39657 km, 717.73 min, 62.97° to ensure daily ground track repeats.

COSMOS 1570 1984-56A, 15031

Launched: 1131, 8 Jun 1984 from Plesetsk by C-1.
Spacecraft data: possibly a cylindrical body with domed ends, similar to Cosmos 1553.
Mission: Military communications using a store-dump technique.
Orbit: 791 x 809 km, 100.91 min, 74.07°.

INTELSAT 5 (F-9) 1984-57A, 15034

Launched: 2300, 9 Jun 1984 from ESMC by Atlas Centaur.
Spacecraft data: Box-shaped body, 1.66 x 2.01 x 1.77 m with attached 4 m aerial mast, the 15 m span solar array has presumably not deployed. The basic mass is 1091 kg.
Mission: Communications satellite in unusable orbit due to early shutdown of the Centaur stage.
Orbit: 176 x 1215 km, 98.50 min, 29.16°.

COSMOS 1571 1984-58A, 15036

Launched: 0840, 11 Jun 1984 from Tyuratam by A-2.
Spacecraft data: Similar to Cosmos 1552.
Mission: Military photo-reconnaissance, recovered after 15 days.
Orbit: 348 x 415 km, 92.20 min, 70.02°.

NAVSTAR 1984-59A, 15039

Launched: 1145, 13 Jun 1984 from WSMC by Atlas.
Spacecraft data: Box-shaped approx. 2 m each side with two solar panels, mass approx 800 kg.
Mission: Navigation satellite.
Orbit: 20318 x 20620 km, 729.61 min, 62.54°.

COSMOS 1572 1984-60A, 15046

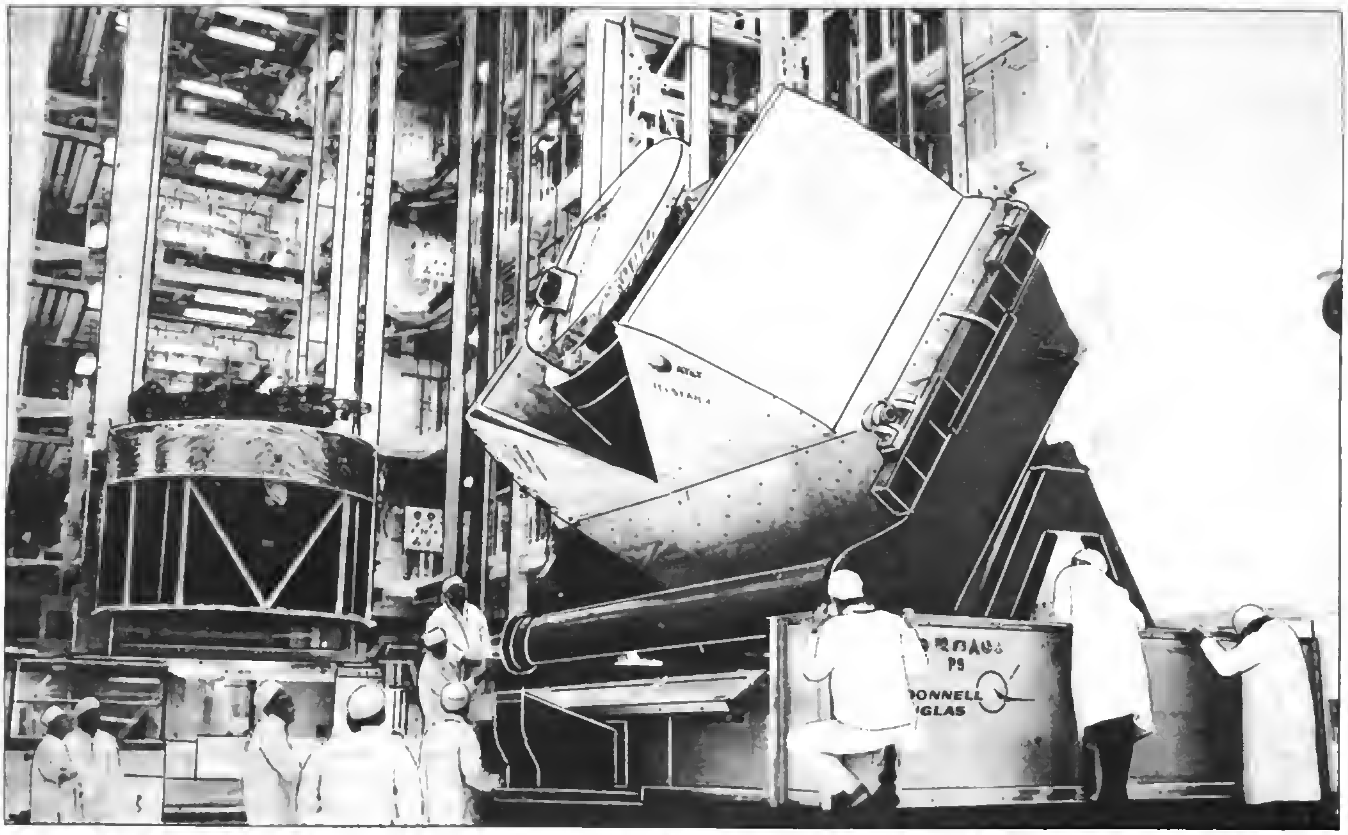
Launched: 0820, 15 Jun 1984 from Plesetsk by A-2.
Spacecraft data: Similar to Cosmos 1552.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package. Recovered after 14 days.
Orbit: 259 x 272 km, 89.88 min, 82.35°.

COSMOS 1573 1984-61A, 15051

Launched: 1055, 19 Jun 1984 from Plesetsk by A-2.
Spacecraft data: Similar to Cosmos 1552.
Mission: Military photo-reconnaissance, recovered after 9 days.
Orbit: 231 x 309 km, 89.95 min, 72.87°.

COSMOS 1574 1984-62A, 15055

Launched: 1940, 21 Jun 1984 from Plesetsk by C-1.



The much-delayed Shuttle 41D mission in early September deployed three satellites. The largest, seen here in the background, was Syncom 4-2 for use by the US Navy. In its launch cradle in the foreground is Telstar 3; the SBS communications satellite completed the trio. *NASA*

Spacecraft data: Similar to Cosmos 1553.
Mission: Navigation satellite, also carrying COSPAS-SARSAT radio receiver package to monitor international distress signal frequencies.
Orbit: 969 x 1008 km, 104.93 min, 82.96°.

RADUGA 15 1984-63A, 15057

Launched: 0020, 22 Jun 1984 from Tyuratam by D-1-E.
Spacecraft data: Cylinder with a pair of solar panels and an aerial array at one end. Length about 5 m, diameter about 2 m and mass around 2000 kg.
Mission: Soviet domestic communications satellite.
Orbit: Geosynchronous above 128° east longitude.

COSMOS 1575 1984-64A, 15060

Launched: 0740, 22 Jun 1984 from Plesetsk by A-2.
Spacecraft data: Similar to Cosmos 1552.
Mission: Photo-reconnaissance, all or part of the payload was an Earth resources package. Recovered after 15 days.
Orbit: 261 x 275 km, 89.93 min, 82.33°.

OPS 1984-65A, 15063

Launched: 1830, 25 Jun 1984 from WSMC by Titan-3D.
Spacecraft data: Cylindrical shape, approx. 15 m long and 3 m diameter, mass around 13000 kg.
Mission: Military photo-reconnaissance, carrying several film return capsules, 'Big Bird' type vehicle.
Orbit: Approx. 170 x 260 km, 96.5°, manoeuvrable.

OPS 1984-65C, 15071

Launched: Piggy back with 1984-65A.
Spacecraft data: Not available.
Mission: Electronic reconnaissance.
Orbit: Approx. 700 km, circular, 96.5°.

COSMOS 1576 1984-66A, 15070

Launched: 1535, 26 Jun 1984 from Plesetsk by A-2.
Spacecraft data: Possibly similar to Cosmos 1552.
Mission: Military photo-reconnaissance.
Orbit: 170 x 351 km, 89.75 min, 67.14°, manoeuvrable.

COSMOS 1577 1984-67A, 15077

Launched: 0500, 27 Jun 1984 from Plesetsk by C-1.
Spacecraft data: Similar to Cosmos 1553.
Mission: Navigation satellite.
Orbit: 959 x 1011 km, 104.86 min, 82.96°.

COSMOS 1578 1984-68A, 15080

Launched: 1403, 28 Jun 1984 from Kapustin Yar by C-1.
Spacecraft data: Not available.
Mission: Not known but probably military.
Orbit: 295 x 1643 km, 104.39 min, 50.69°.

COSMOS 1579 1984-69A, 15085

Launched: 0026, 29 Jun 1984 from Tyuratam by F-1.
Spacecraft data: Not available.
Mission: Radar reconnaissance over ocean areas, powered by a nuclear reactor.
Orbit: 249 x 264 km, 98.65 min, 65.00°, maintained by a low thrust motor.

COSMOS 1580 1984-70A, 15090

Launched: 1500, 29 Jun 1984 from Plesetsk by A-2.
Spacecraft data: Similar to Cosmos 1552.
Mission: Military photo-reconnaissance, recovered after 14 days.
Orbit: 243 x 347 km, 90.41 min, 62.82°.

COSMOS 1581 1984-71A, 15095

Launched: 2131, 3 Jul 1984 from Plesetsk by A-2-e.
Spacecraft data: Possibly similar to the Molniya satellites.
Mission: Missile early warning satellite.
Orbit: Initially 617 x 39260 km, 708.11 min, 62.97°, then raised to 639 x 39707 km, 717.61 min, 62.95° to ensure daily ground track repeats.

METEOR 2(11) 1984-72A, 15099

Launched: 0337, 5 Jul 1984 from Plesetsk, possibly by F vehicle.
Spacecraft data: Cylindrical body with two, Sun-seeking solar panels, length about 5 m, diameter about 2 m and mass around 2200 kg.
Mission: Meteorological satellite returning visible and infra-red images of cloud cover and the Earth's surface for remote sensing.
Orbit: 943 x 960 km, 104.15 min, 82.53°.

BOOK NOTICES

Space: A Developing Role for Europe

Eds. L.J. Carter & P.M. Bainum, American Astronautical Society, Publications Office, P.O. Box 28130, San Diego, California 92128, USA, 1984, 278pp, $45.

Members of the Society will be particularly interested in this volume which presents the proceedings of the 18th European Space Symposium hosted by our Society in London in June last. It deals with European Space projects for the 1980's and 1990's, including future prospects, space science programmes, micro-gravity research, remote sensing and telecommunications satellite programmes. Other contributions cover launch vehicles and space platforms.

Those members who attended the 18th European Space Symposium will know that it was a highlight in the Society's Calendar of Activities. The standard of presentation was very high and, although many of the papers presented appeared subsequently in *JBIS* or *Spaceflight*, this work now brings the proceedings of the meeting together in a single volume.

This work constitutes volume 56 of the Science and Technology series of the AAS.

Note that BIS members receive a 25% discount on all AAS books, including both the 17th and 18th European Space Symposia. Overseas mailing charges are $3 for the first book and $1 for each additional book.

Cecilia Payne-Gaposchkin - An Autobiography

Ed. K. Haramundanis, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 2RU., 269pp, 1984, £19.50.

Cecilia Payne-Gaposchkin has been called "probably the most eminent woman astronomer of all time." Her own story of her professional life, work and scientific achievements is augmented in the present volume by personal recollections of her daughter, a scientific appreciation of her work and an historical essay.

Cecilia Payne-Gaposchkin had an overwhelming love for astronomy, for which she received many prestigious awards for her outstanding contributions. In 1956 she became the first woman to become a Professor at Harvard University. This volume is interesting not only for the background information on her attitudes and contributions to astronomical thought but also because it sheds a revealing light on the status and potential for the advancement of women in the scientific community.

Colours of the Stars

D. Malin and P. Murdin, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 2RU, 198pp, 1984, £13.95.

Colour is a necessary ingredient to the interpretation of what we see. This is a difficult area for the amateur astronomer for stellar objects seen through the telescope exhibit colour which is real enough but very subtle. A number of books for the amateur astronomer mention the hues of some of the stars but this is the first time that a volume has appeared devoted solely to the colours of celestial objects. Photography has extended this vision and, for the first time, this book collects over 60 colour photographs, principally taken with 3.9 m Anglo-Australian Telescope and the 1.2 m UK Schmidt telescope to show how colour can help interpret the evolution and temperature of stars, recognise similarities and differences in the structure of galaxies and nebulae and even examine the fine traces of dust in interstellar space.

A considerable amount of false colour has been used in pictures in the past so that the provision of plates showing true colour is of considerable interest, expecially as many of the pictures have not been published before and few seen outside specialist journals. Many black and white photographs have also been included using new techniques to try to produce the full range of light within the astronomical objects examined.

The result is a clear, practical explanation of the photographic techniques used, together with an account of the history of photography in astronomy since it first began, just over 100 years ago.

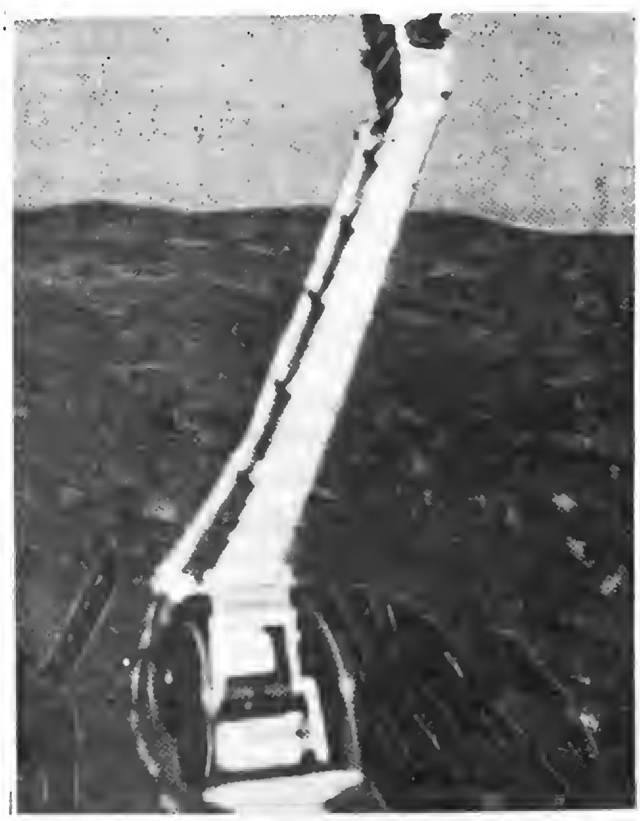
The Surface of Mars

M.H. Carr, Yale Univ. Press, 13 Bedford Sq., London WC1B 3JF, 232pp, 1984, £19.95.

This is a softcover edition of a well-received book first published in 1981. The modern era of Mars exploration began in July 1965 when Mariner 4 flew by at a distance of 9,780 km. The first pictures revealed an apparently dead, cratered surface much like that of the Moon. There was no indication of the canals and oases of earlier maps and the prospects for life on Mars dimmed considerably. This somewhat disappointing result was confirmed by Mariners 6 and 7 which, in 1969, sent back more pictures of a cratered surface and confirmed that the atmosphere was thin, less than one-hundredth that of Earth, and composed primarily of carbon dioxide. It was not until 1971 that the geological diversity of the Martian surface was revealed. Following a series of misadventures, which included losing one spacecraft and arriving at the planet only to find it almost completely hidden from view by atmospheric dust, Mariner 9 started to map the planet systematically early in 1972.

The Mariner 9 pictures revealed a strange planet with huge volcanoes, vast canyons, and what were seemingly enormous dry river beds. They showed that the earlier spacecraft had fortuitously passed over only the older parts of the planet where a primitive, densely cratered surface was preserved. Much of the surface was clearly younger than that seen earlier and had

Images from the Viking landers on the surface of Mars were processed to enhance detail and contrast. *NASA*



been subject to a wide variety of geologic processes which had created features of surprisingly large dimensions, considering the rather modest size of the planet, a little over half that of Earth. The presence of what appeared to be river channels was particularly exciting. By that time it was known that liquid water is unstable on the Martian surface so, in order for the channels to have been cut by water, more clement climatic conditions must have existed in the past.

The latest probes were the 1976 Viking landers and orbiters. Both landers operated for several years and, while they detected no life, returned an enormous amount of data on the chemistry of the soil, the meteorologic conditions of the landing sites and local landforms. By the end of the orbiters' mission in August 1980 they had taken close to 55,000 pictures of the planet, from which most of the illustrations in this book have been selected.

The Viking spacecraft confirmed and added to the impression of geologic diversity. Well-integrated valley networks were observed, implying that parts of the surface have been subjected to the slow erosion of running water. Other, much larger, channels suggest episodic floods of enormous magnitude. Collapsed ground, morainelike features, and surface scours suggest the action of ice, while giant landslides and rock glaciers indicate mass wasting on a grand scale. The ejecta patterns around impact craters indicate that liquid water and ice may exist at relatively shallow depths below the surface. Vast sand seas around the poles attest to the efficacy of wind transport. Lava flows hundreds of kilometres long bear witness to repeated large eruptions of fluid lava and the presence of sparsely cratered volcanoes suggests that volcanism has continued into the relatively recent geologic past.

The book is aimed at the informed scientific reader. A working knowledge of physics and chemistry and a familiarity with scientific units are assumed. Also assumed is a basic vocabulary of geology, although the use of specialised terms is avoided where possible. Additional chapters on the search for life and on the two moons, Phobos and Deimos, are not strictly about Martian geology but are closely related to the central theme. The main body of the book closes with a short summary of the geologic history (chapter 16). Appendices include a commentary on how the Viking orbiter pictures were acquired, a guide to the use of the pictures and information on the availability of maps of Mars.

Astronomy with Schmidt-Type Telescopes
Ed. M. Capaccioli, D. Reidel Publishing Co., P.O. Box 17, 3300 AA Dordrecht, Holland, 1984, 619pp, $84.

Surprisingly, at no time during the last ten years in spite of the remarkable developments and achievements with Schmidt telescopes, no earlier volume on this important topic has appeared.

For example, two powerful Schmidt telescopes have just entered operation in the southern hemisphere i.e. ESO 1 m at La Silla in Chile and the UK 122 cm with an objective prism of the same size at Siding Spring, in Australia, both currently being used to extend the Palomar Sky Atlas to the southern hemisphere. High sensitivity emulsions and new photographic techniques have increased the efficiency of the Schmidt telescopes which can operate from the ultraviolet to the infrared. Moreover, there are several proposals to put large Schmidt telescopes into orbit to enable them to scan the whole of the sky in the far ultraviolet. Since the Schmidt telescope produces a very large amount of material, techniques have also been introduced for the automated fast reduction of the wide field plates with the highest possible precision.

This volume provides up-to-date information on the state of the art and future plans in the field of wide-angled telescopes. There 70 contributed papers dealing mainly with new results together with 24 review papers.

Topics dealt with include photographic and objective prism surveys; photographic and data acquisition techniques and reduction methods (hardware and software); astrometry from ground and space; Solar System astronomy with emphasis on comets; Galactic astronomy (galactic structure, spectral classification, variable stars, nebulae, interstellar matter, supernovae); extragalactic astronomy (normal and active galaxies, peculiar morphologies, QSO's and clusters/superclusters); star and galaxy counts (techniques and results); observational cosmology, ground- and space-based future developments of Schmidt astronomy (new surveys, all reflective wide-field telescopes, detectors and interaction with the Space Telescope).

Most of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.

Cool Stars, Stellar Systems and the Sun
Eds. H. Araki, *et al*, Springer-Verlag, Heidelberger Platz 3, Postfach, D-1000 Berlin 33, 1984, 364pp, $18.90.

This volume includes the papers presented at the Proceeding of the third Cambridge Workshop on the subject held in 1983 and is Vol 193 in a series entitled "Lecture Notes and Physics."

The meeting was structured on the theme of stellar evolution, beginning with pre-main sequence stars and continuing with main sequence evolution and the post-main sequence red giant phase. Besides these main sections, some of the IRAS results are presented together with a special section on Alpha Orionis (Betelgeuse), a particular case of a red giant.

Included in the pre-main sequence papers are a number of observations on star formation, particularly the T Tauri stars, generally regarded as low mass objects distinguishable by a distinctive set of spectral characteristics.

Although the volume is relatively small it includes about 60 contributions. All are as originally typed i.e. reproduction has been made direct from the initial typed scripts even though the result gives a rather uneven appearance.

Remote Sounding of Atmospheres
J.T. Houghton, F.W. Taylor and C.D. Rodgers, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 2RU, 343pp, 1984, £35.

Remote sounding techniques are growing rapidly in importance as a means for studying the structure, climate and weather of the atmospheres both of the Earth and of other planets in the Solar System, with measurements from satellites and space probes proving particularly useful because they allow good coverage, often at high resolution. Remote sounding techniques involve the measurement of atmospheric parameters from a distance. The feature which they all have in common is that the instrument making the measurement is far from the point at which the measurement is being made. This contrasts, for example, with routine meteorological techniques performed by injecting instruments into the region to be examined, e.g. using balloons.

The book shows how measurements can be made of the properties of the atmospheres of the Earth and planets. Requirements are for a complete description in the fields of atmospheric density, motion and composition over the whole glnbe and at all important heights. The net input of energy also needs to be measured as does the exchange of heat, momentum and water vapour with the surface.

It includes descriptions of the scientific principles, technical implementation, mathematical methods of analysing the measurements obtained and a history of measurements made and phenomena discovered and studied using remote sounding. The techniques are important for meteorology, climatology and an understanding of man's impact on the Earth's atmosphere.

Astrophysics and Twentieth-Century Astronomy to 1950 (Vol. 4 Part A)
Ed. O. Gingerich, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 2RU, 198pp plus appendices, 1984, £17.50.

This volume is one of a series on the history of astronomy, concerned with the birth of modern astrophysics in the nineteenth century, the growth of astronomical institutions up to about 1920 and the parallel development of instrumentation.

It begins in the 1850s (when Foucault discovered the technique of depositing silver on glass) with the first astronomical applications of photography and spectral analysis, closing in the 1950s before another explosive growth, stemming from computers and other electronic devices e.g. by 1949 the first discrete radio sources had been discovered and identified and, by 1951, the distance scale of the Universe revised and the spiral arms of the Milky Way detected both by conventional and optical means.

Part A consists of 11 chapters written by 18 authors. Topics covered include the origins of astrophysics, the development of photography, variable stars and stellar evolution and the H-R diagram. The chapter on observatories is expanded by descriptions of some of the world's largest telescopes and other instrumentation. The text is written not solely for historians but directed to the general reader.

Secrets of the Sun

R. Giovanelli, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 2RU, 116pp, 1984, £11.95.

When the first sunspots were observed in 1611 by Fr. Scheiner, his superiors assured him that they did not exist and advised him to "tranquillize himself." Fortunately, he did no such thing, nor did the many later observers who have contributed to knowledge of what is, actually, the nearest star to us and which is - undoubtedly - very similar to the majority of stars in the sky.

The phenomena which occur on the Sun are spectacular but almost totally concealed by its dazzling brilliance. This is why a book for the non-specialist which explains, simply, the mysteries of sunspots, solar rotation, solar flares, prominences and the corona, all illustrated with spectacular photographs, is to be highly commended.

Atlas of Deep-Sky Splendors

H. Vehrenberg, Cambridge University Press, The Edinburgh Building, Shaftesbury Road, Cambridge CB2 2RU, 242pp, 1984, £25 H/c.

The text gathers into one volume a selection of high-quality wide-field photographic charts showing over 400 galaxies, star clusters and nebulae, including all the Messier objects, presented to a standard scale and surrounded by large star fields. Scientific data and introductory essays on various astronomical subjects together with large-scale observatory photographs of many of the celestial objects shown accompany the charts.

The purpose behind the book was to help amateur astronomers to pin-point faint objects in the night sky and thus obtain maximum possible benefit from his observations.

A total 114 star fields have been chosen, the significant objects in each being identified by a finder chart. Some 1,300 square degrees are covered by the charts, altogether, so plenty of "landmark" stars appear in fields this size, thus making it easy to locate faint objects precisely With a lower magnitude limit of about 17, challenges are offered to owners of even the larger instruments.

The accompanying text for what is now the fourth edition has been updated once again to try to keep up with the continuing explosion in astronomical knowledge.

Manual of Remote Sensing, Vols 1-2 (Second Edition)

Ed R.N. Colwell, American Society of Photogrammetry, 210 Little Falls Street, Falls Church, Virginia 22046, USA, Vol. 1 1232pp, Vol 2. 1208pp, 1983, $125.00 plus pp.$18.

Remote sensing encompasses the total observational process from remote platforms. Typically, it entails the use at a distance (as from ships, aircraft and spacecraft) of any system for gathering information on the environment. Techniques employ such devices as the camera, lasers, radio frequency receivers, radar systems, sonar, seismographs, gravimeters, magnetometers and scintillation counters.

When the first edition of this two-part manual originally appeared in 1975, it represented the state-of-the-art as then known. In the few years that have elapsed since the procedure has been profoundly altered in leaps and bounds by advances in high technology - with the result that many of the practices described in the original edition have become outmoded - so a new edition is very much to be welcomed.

The result is largely a new work rather than a revision of the original text. Its contributors represent a broad spectrum of scientific and other interest in this field.

One of the major new sections in this second edition is a comprehensive chapter on geological applications - a field in which very substantial advances have been made in recent years.

Volume 1 is concerned with "theory, instruments and techniques." It contains 25 main sections ranging from the development and principles of remote sensing, through the nature of electromagnetic radiation and up to various types of instruments and transmission systems including data processing, pattern recognition, ground truth, etc.

Volume 2 deals with the applications of these principles to a wide variety of scientific fields, including archaeology, anthropology, marine and water resources, land resources and even with a final chapter on observations of the Moon and planets.

EDITORIAL

Concluded from p. 386

won the day, the telescope would not even be there as "a desirable robot instrument."

The fact that robot equipment is beloved by some in the scientific fraternity undoubtedly discloses a measure of self-interest. It shows some scientists as less than pure by putting their own interests above those of mankind and human destiny. The fact is that the Earth is a cradle. They are attempting to condemn man to live in this cradle for the rest of his existence.

Of course, everyone knows that robots have an essential role in space exploration, as does man. It belittles man to argue that he does not want to go into the Universe and explore every nook and cranny for himself. The world is full of people shifting ceaselessly in their endeavours to experience new things for themselves.

The true purpose of robots is to pave the way, to go where man cannot go, and help him to explore further than before. Mankind will decline if he ignores the Galaxy and stays a recluse on Earth. Scientists who argue thus seek to exchange our birthright for a mess of pottage. H. G. Wells had it better when he said "it's the Universe, or *nothing.*"

8. *It cannot reach many satellites*

Nor could early rockets venture far into space either. Nor, indeed, can a child who walks for the first time take many steps. We have to walk before we can run. Is not this already known to *everyone*? Who would argue that there will *never* be ways and means of reaching more distant orbits from space stations?

9. *It is a science fiction idea*

This is a further example of innuendo by attempting to suggest that the space station concept is unrealistic. It simply insults and offends and produces no case at all.

This Horizon programme reflected sadly on BBC standards of presentation. An opportunity for thoughtful discussion and clarification of the potentialities of man's future in space was sacrificed for the terminating snappy punchline and innuendo.

A sad and jaundiced way, indeed, of honouring the first Apollo moonwalk of 15 years ago.

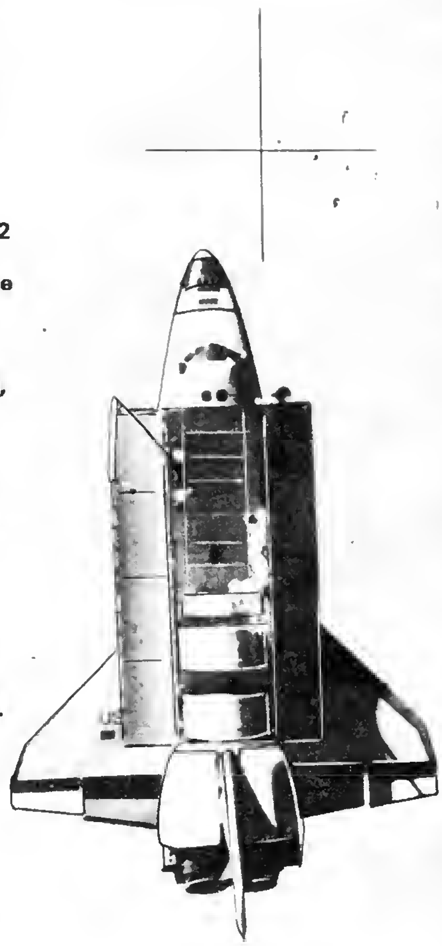
SOCIETY BOOKS

PROJECT DAEDALUS

The publication of the Project Daedalus Final Report marked the end of years of painstaking work by a group of BIS pioneers. The BIS received congratulations from around the world for its far-sighted project: designing a probe for man's first crossing of interstellar space.

The Final Report Report contains 24 papers spread over 192 large-format (A4) pages, summarising the four year study. The papers cover the overall spacecraft design, mission profile, computer systems, navigation, experiments and our knowledge of nearby stellar systems, some of them possibly with planets.

"Daedalus" is acknowledged as a milestone in the the development of advanced astronautics. Copies of the Report cost just £7.00 ($11.00) post free.



THE EAGLE HAS WINGS

An exciting progression of space achievements in the years following the Second World War led to Man's first landing on the Moon in 1969. Rockets for probing the upper atmosphere evolved into the space launchers we know today. Vanguard, Explorer, Atlas, Titan, Mercury, Gemini, Apollo – a succession of names to conjure up memories of the 50's and 60's when man was taking his first tentative steps into outer space.

The Eagle Has Wings tells the story of the major US Space projects from 1945 to the watershed year of 1975, when the Apollo missions came to an end and the first wave of interplanetary exploration gave way to the more sophisticated probes of today. Written by *Spaceflight* managing editor Andrew Wilson, it is packed with information and photographs. It runs to no less than 144 large-format pages and can be obtained for the low price of £7 ($11.00) post free.

HIGH ROAD TO THE MOON

Every member ought to own a copy of this unique 120 page publication which records many of the Society's early ideas and discussions on Lunar exploration in the visionary drawings and illustrations of the late R. A. Smith.

Pictures and drawings detail plans for orbital rockets, space probes and ships to take men to the Moon and Lunar exploration. Some are familiar illustrations used in books of the time: others have not been published before.

Bob Parkinson has brought these pictures together with a commentary which tells how the pioneers imagined things would be and how they actually were. It goes beyond the present, for man's involvement with the Moon is not yet finished. Using the Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.

Price: £6.00 ($9 .00) post free.

All of the books are available from: The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ, England

spaceflight

Correspondence, manuscripts intended for publication and requests for information on membership may be addressed to the Executive Secretary at the Society's Offices at 27/29 South Lambeth Rd., London SW8 1SZ. Tel: 01-735 3160.

NOTICES OF MEETINGS

Lecture
Title: **IRAS: 300 DAYS OF DISCOVERY**
by Dr. John Davies
Leicester University

The Infrared Astronomical Satellite made the first all-sky survey in the infrared, discovering six comets, a dust shell around Vega and star-forming regions in the Galaxy and beyond. Dr. Davies, closely involved with the survey, will describe this exciting mission.

To be held in the Society's Conference Room, 27/29 South Lambeth Rd., London SW8 1SZ on **24 October 1984**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time, enclosing a stamped addressed envelope.

Space '84
The Space '84 "weekend" will be held in Brighton on **16–18 November 1984**. See inside this issue for details.

SCIENCE MUSEUM VISIT

A special visit to the London Science Museum has been arranged for Society members on **4 December 1984**, 6.30-9.15 p.m. The programme will consist of visiting the 'Exploration' and 'Telecom' sections, hearing a short talk by Dr. John Becklake on other Space Museums in the Lecture Theatre and viewing a number of video films.

A buffet with wine will be provided at the Museum during the course of the evening.

The party will be limited in number so advance registration is essential; a fee of £5 will be charged to cover costs. Forms are available from The Executive Secretary, The British Interplanetary Society, 27/29 South Lambeth Road, London SW8 1SZ.

Film Show
Theme: **MOMENTS IN HISTORY (PART 1)**

The first of two meetings devoted to historical space films will be held in the Society's Conference Room, 27/29 South Lambeth Rd., London SW8 1SZ on **9 January 1985**, 7.00-8.30 p.m.

The programme will include the following:

(a) The Dream that Wouldn't Down
(b) High Altitude Research
(c) Down to Earth
(d) Vanguard Satellite
(e) Live *via* Early 8ird
(f) The Viking Rocket

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed envelope.

Film Show
Theme: **MOMENTS IN HISTORY (PART 2)**

The second of two meetings devoted to historical space films will be held in the Society's Conference Room, 27/29 South Lambeth Rd., London SW8 1SZ on **6 February 1985**, 7.00-8.30 p.m.

The programme will include the following:

(a) A Man's Reach Should Exceed his Grasp
(b) Small Steps, Giant Strides
(c) A Moment in History
(d) Blue Planet
(e) Meteosat

Admission is by ticket only. Members wishing to attend should apply in good time, enclosing a stamped address envelope.

Lecture
Theme: **COMMERCIAL LAUNCH VEHICLES**
By G.M. Webb

To be held in the Society's Conference Room, 27/29 South Lambeth Road, London SW8 1SZ on **20 February 1985**, 7.00-9.00 p.m.

Admission is by ticket only. Members should apply in good time enclosing a stamped addressed enveloped.

One-day Symposium
Theme: **SPACE STATIONS**

A one-day symposium on the obove theme, considering the technology and applications of Space Stations, will be held in the Society's Conference Room on **17 April 1985**.

Offers of papers are invited. Potential authors are requested to contact the Executive Secretary, at 27/29 South Lambeth Road, London SW8 1SZ.

LIBRARY

The Library will be open to members from 5.30 to 7 p.m. on the following dates:

24 Oct 1984
14 Nov 1984
5 Dec 1984
9 Jan 1985
6 Feb 1985

While every effort will be made to adhere to the published programme, the Society cannot be held responsible for any changes made necessary for reasons outside its control.

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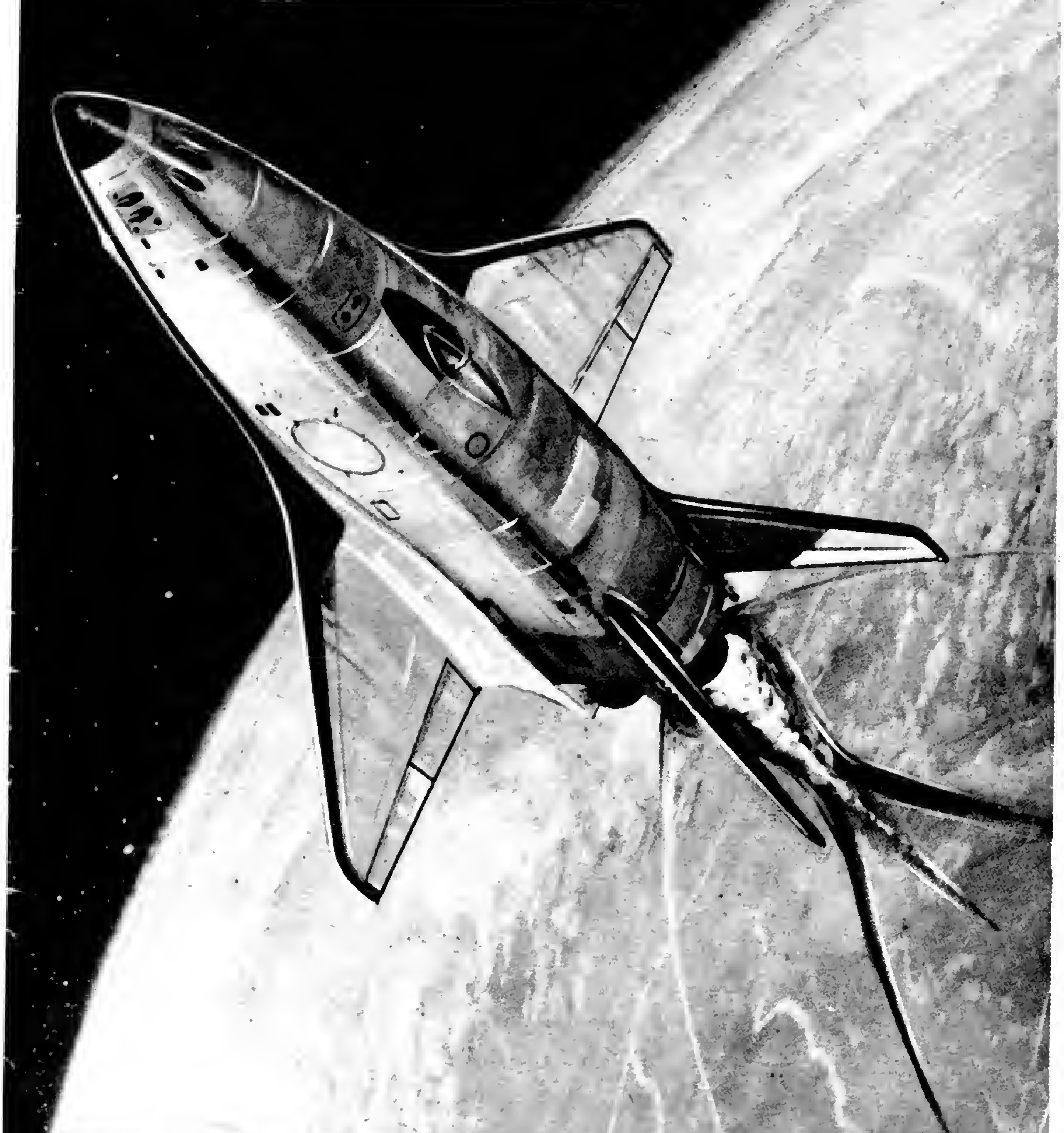

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CONTENTS

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SPACE - THE EUROSPACE VIEWPOINT

Eurospace, the European Association of Space Companies, has always recognised the need for Europe to have a coherent, well balanced and reasonably long term (at least 15 years) space programme if it is to have a chance of becoming a space power of consequence.

It has become obvious to Eurospace in the last few years that the tide of events is crowding in on Europe with the prospects of industrialisation in space (e.g. use of the microgravity and vacuum environment), the commercialisation of Earth resources data and the development of new transportation systems such as the Shuttle. Thus, a new and more vigorous effort is required on a fairly long term basis to ensure that, ultimately, Europe will acquire sufficient independence to allow it to become, and remain, competitive in world markets for space products and the associated technology.

Over the last 18 months or so, Eurospace has studied, in some depth, the motivation and requirements for a well-balanced long term (15 years) space programme. This work, in which all the Eurospace industrial members participated and which was the subject of several top-level meetings with ESA, produced plans for a range of projects and associated technology with estimated costs.

The plans considered are of two types. First are space transportation systems (including in-orbit infrastructure); second are scientific, Earth observation and telecommunications satellite projects. The first category comprise Ariane and post-Ariane 4 development with provision for man-rated operations by 1997, the HM6 cryogenic motor development being a necessary associated requirement. Also included is a manned hypersonic glider (Hermes project) with a development phase to be finalised by 1997. The manned station and laboratories requirements for this category include additional Spacelabs and a module for docking with the US space station. The Columbus project is a suitable candidate for this requirement as it could eventually evolve into an autonomous space station by the year 2000. The ESA Eureca concept and the co-orbiting platform element of Columbus will provide unmanned platforms. A permanent polar platform for Earth observation is a further possibility. Finally, the development of a space service vehicle for polar and geostationary satellites should also be considered. The second category of projects comprise a second generation Meteosat - a polar meteorological satellite, a climatological satellite, Popsat (solid Earth physics), ERS 1&2 (coastal and ocean observation) and ERS A&B

Continued overpage

COVER
This 7-18 tonne payload shuttle concept for the future was developed by Rockwell. Lift-off weight is 700 tonnes, of which 88% is accounted for by cryogenic propellants. Possibility for second generation shuttle vehicles are discussed by M.W. Jack Bell in this month's *JBIS* 'Space Technology' issue.
Rockwell

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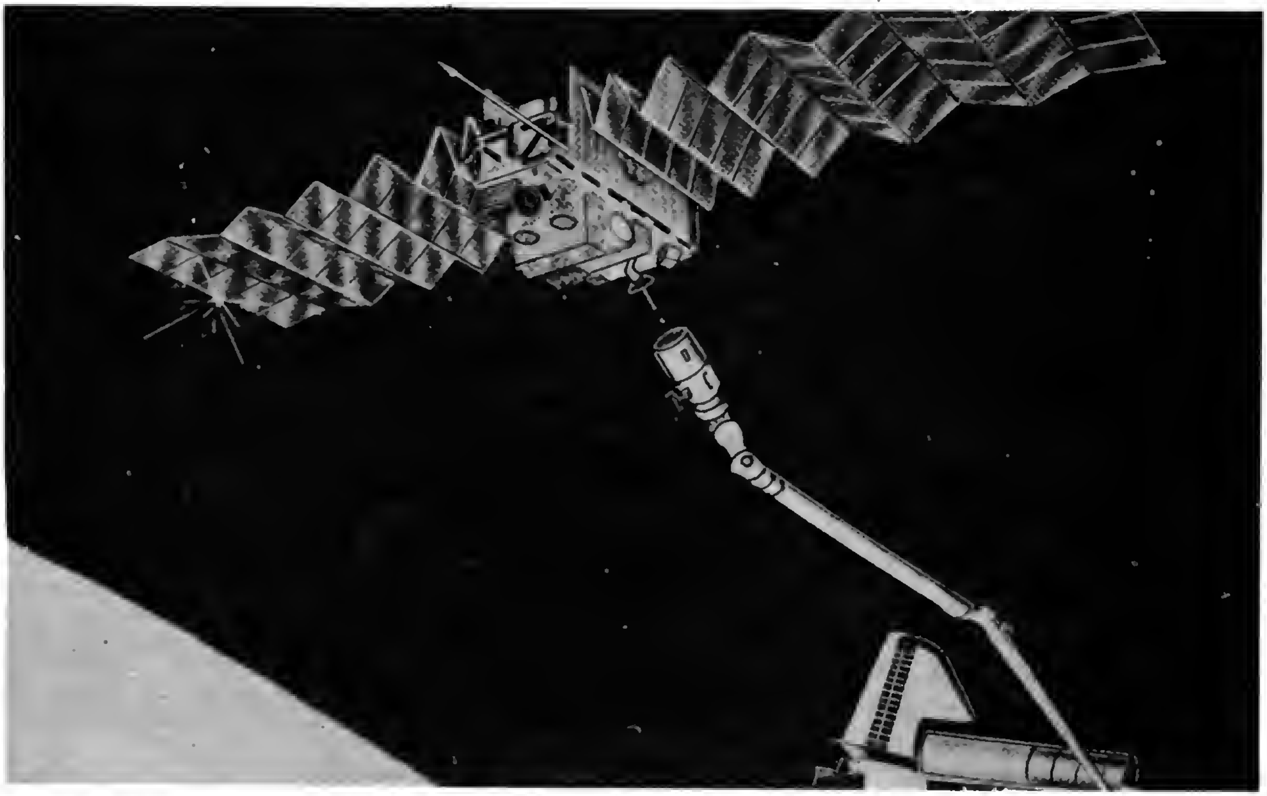


The European Eureca free-flying platform concept.

(land observation) to meet Earth observation and meteorological requirements. A data relay satellite, a satellite for mobile services and two technological satellites (AOTS 1&2) comprise the communications part of the programme.

ESA submitted its own Space Plan to its Council last June, with Eurospaçe proposals also made available to Delegates at the same time. As Eurospace and ESA recommendations proved to be very similar, the philosophy behind the Eurospace plans can be considered as an acceptable European viewpoint. This is summarised as follows:

1. To a far greater extent than in the past, the commercialisation of space is becoming a significant factor in assessing the value of a country's contribution to space activity, not only in the communications field but for Earth observation and, in particular, industrialisation in space by the end of the century.
2. European industry's workload is currently diminishing. Many companies, especially those in smaller countries which lack a national programme, will be affected. Hence, a new government effort is required to improve European competitivity in the space field. The important projects are those that will provide Europe with the capacity to compete, in particular, in the provision of low cost transportation of equipment into orbit and the establishment of facilities for exploiting the space environment.
3. Eurospace supports ESA in its role as manager of a major, well-balanced long-term programme in which all Agency member-countries participate according to their gross National Products. Some companies will have specific expertise which will be reflected in their countries' interest in particular projects, though it is hoped that optional projects will be limited and that a broad basic programme will re-establish sound competition between consortia with a more equitable distribution of the available contracts.
4. Regarding collaboration with non-European partners on major projects, such as the Space Station, negotiations should be handled by ESA but only on a basis whereby Europe enjoys freedom of access and utilisation of the facilities with acceptable technical, managerial and financial terms, and provided that such cooperation is a step towards an ultimate independent European system.

The estimated costs of this programme, including development costs, average about 1500 MAU over the 15 year period considered. About 44% of this covers the space transportation category of projects. This level is of the same order as that estimated for the ESA Space Plan and is not excessive since it represents only about a 30% increase over the ESA 1978 budget when inflation is taken into account. The current US space expenditure, including NASA and DoD, in terms of its R&D public expenditure and GNP, is six or seven times greater that the comparable European space expenditure even with the proposed increase. Thus, the proposed budget can be considered to be reasonably modest.

A further economic advantage of the proposed programme is the marked impact on the balance of payments that will arise from the possession of a European launch vehicle for its own use and for launching non-European satellites, besides the benefits that the satellites themselves will provide.

Politically, the proposed programme should foster European unity, e.g. through the use of direct broadcast satellites. It will also generate greater public interest and support when it becomes clear that Europe is playing a decisive role in space.

MILESTONES

August 1984

27 Pres. Reagan anounces that a schoolteacher will fly aboard the Shuttle in late 1985 or early 1986. The specific requirements will be released in early October.

27 NASA is beginning work on the Extreme Ultraviolet Explorer satellite for a 1988 launch.

29 The 3rd ground firing of the Inertial Upper Stage is successful; the 4th and final test is planned for October to re-qualify the stage for Shuttle flight. IUS is due to be used on Shuttles in December and February.

September 1984

5 Shuttle *Discovery* lands at Edwards AFB in California.

7 Salyut 7 cosmonauts Kizim, Solovyov and Atkov exceed the space endurance records of 211 d held by Anatoly Berezevoi and Valentin Lebedev. To set a new record, they must exceed the old one by at least 5%.

11 The first of two lithium releases is made from the German AMPTE satellite just outside the magnetosphere. The second occurs on the 20th. A large barium release will be made in late December to produce an artificial comet.

12 China launches its 12th satellite; recovery is made 5 d later. It is believed to be a reconnaissance vehicle test.

12 A dress rehearsal for the launch of Shuttle 41G on 5 October is successfully completed with all seven astronauts aboard *Challenger*.

14 NASA issues requests for proposals for definition and preliminary design of Space Station; responses are due in by 15 Nov.

21 The last NASA Delta rocket to carry a commercial satellite is successfully launched with the Galaxy 3 communications satellite.

24 NASA Administration James Beggs must decide by 1 Dec. if Galileo should fly past asteroid Amphitrite on 6 Dec. 1986 on its way to Jupiter.

24 RCA Astro-Electronics and Hughes Aircraft Co. will take over operation of the US Landsat programme. Landsats 6 and 7 will be launched in 1988 and 1991.

27 India has accepted NASA's offer to fly a payload specialist aboard the Shuttle in 1986.

October 1984

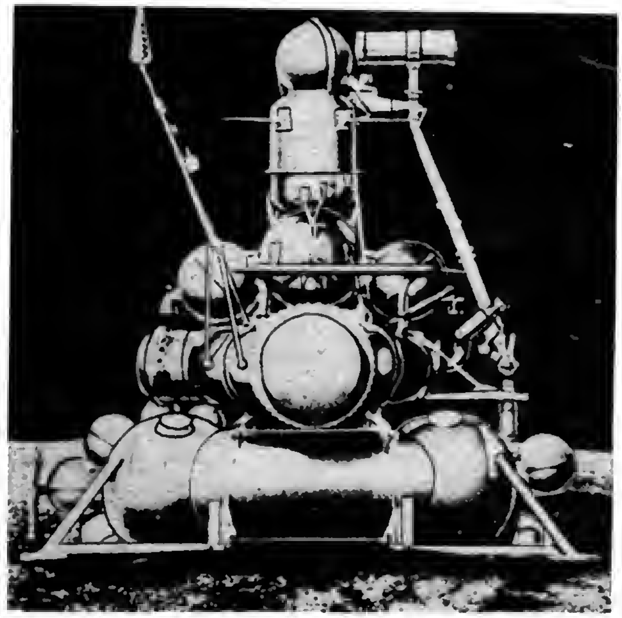
2 Cosmonauts Kizim, Solovyov and Atkov return to Earth after a record 237 d flight.

5 Shuttle *Challenger* is successfully launched to begin the 41G mission.

Please note that some of the dates quoted above refer to the "announcements" of the events and not necessarily to the events themselves.

DO YOU KNOW?

Can you identify this spacecraft and identify what it is doing? Answer below the picture.



Novosti

Answer: This is a representation of the Soviet Luna 16 probe, launched on 12 September 1970, which brought back a 100 g sample of lunar soil. The drill at the end of the arm extracted a core from the surface then deposited it into the Earth-return capsule at top. The upper stage (the cylinder below the sphere) then ignited to take the capsule back to Earth for recovery.

DO YOU REMEMBER?

25 Years Ago...
4 December 1959. Little Joe (LJ-2), Mercury capsule abort test, is launched from Wallops Island, Virginia, with rhesus monkey Sam aboard. Sam and capsule are recovered successfully after reaching an altitude of 30 km.

20 Years Ago...
28 November 1964. Mariner 4 is launched by Atlas Agena from Cape Canaveral towards Mars. The craft successfully flew past the planet the following July, returning 21 pictures showing a cratered Martian surface for the first time.

15 Years Ago...
21 November 1969. The UK's Skynet 1 is launched by Delta from Cape Canaveral to act as Britain's first synchronous military communications satellite.

10 Years Ago...
8 December 1974. Cosmonauts Filipchenko and Rukavishnikov return after the five day Soyuz 16 mission, a dress rehearsal for the 1975 Apollo-Soyuz joint US-USSR flight. During the flight the crew simulated all the major aspects of the ASTP mission, including testing the docking system.

5 Years Ago...
15 December 1979. The first attempt to launch Ariane L01 from Kourou, French Guiana is stopped only one second after engine ignition because of two pressure sensors providing a false reading. A successful launch took place on the 24th.

K.T. WILSON

SEARCHING FOR EXTRATERRESTRIAL ARTIFACTS

By Dr. Robert A. Freitas

The Fermi Paradox, attributed to a famous question from physicist Enrico Fermi in 1943, asks: if there are intelligent beings elsewhere then, in time, they must achieve the technology of nuclear power and space flight and would explore and colonize the Galaxy. Thus, they should have been able to travel to Earth, but we see no evidence of such visitations. Ergo, they cannot exist. The author, of the Xenology Research Institute in California, discusses this viewpoint and suggests how and where we might be able to detect an alien presence in the Solar System.

Introduction

If we believe in the technology, Fermi is saying, we cannot believe in extraterrestrial life. It is a question of "Where Are They?" All discussions of the Fermi Paradox have made one critical assumption that should be challenged: the absence of extraterrestrials or their artifacts on Earth or in the Solar System is an undisputed fact. Actually, the vastness of our ignorance in this area is not generally appreciated.

The idea that aliens might have sent an interstellar probe here to reconnoitre our star system and its environs is not implausible. We sent Viking to Mars to search for life. The alien device would be something like our own interstellar probes, the four Pioneer and Voyager spacecraft, but more sophisticated.

A typical alien probe might be 1 to 10 m in size, large enough to house a microwave antenna to report back and to survive micrometeorite impacts for millions of years, yet light enough to fly across the interstellar abyss without consuming too much energy. Where might it be? Finding it is rather like searching a beach for one special, oddly-shaped grain of sand.

Where Have We Looked?

A spherical Solar System boundary enclosing the orbit of Pluto consists of 260,000 cubic AU (astronomical units, the mean Sun-Earth distance) of mostly empty interplanetary space and 10^{11} km^2 of planetary and asteroidal surface. To be able to say for certain that there is no alien presence in the Solar System, a careful search would have to be made for artifacts.

The ability of a telescope to detect faint objects is measured by its visual magnitude limit. The unaided eye can see down to sixth magnitude. The sky is exhaustively and repeatedly surveyed by amateurs to, at best, magnitude +14. The Palomar Schmidt Sky Survey extends to +21, but these plates are just 'snapshots' of small areas and cannot be counted as a search. The best telescope on Earth reaches only to +24.

These three magnitude limits correspond roughly to an unmoving, mirror-shiny, optimally-oriented 10 m object orbiting at 0.01, 0.25 and 1 AU from Earth, respectively. A smaller, moving, dark or angled object would be even harder to see. So we can scan at best only the nearest cubic AU of space for probes, but there is 260,000 cubic AU to search. Even if Mount Palomar was employed exclusively to look for alien artifacts it could scan only

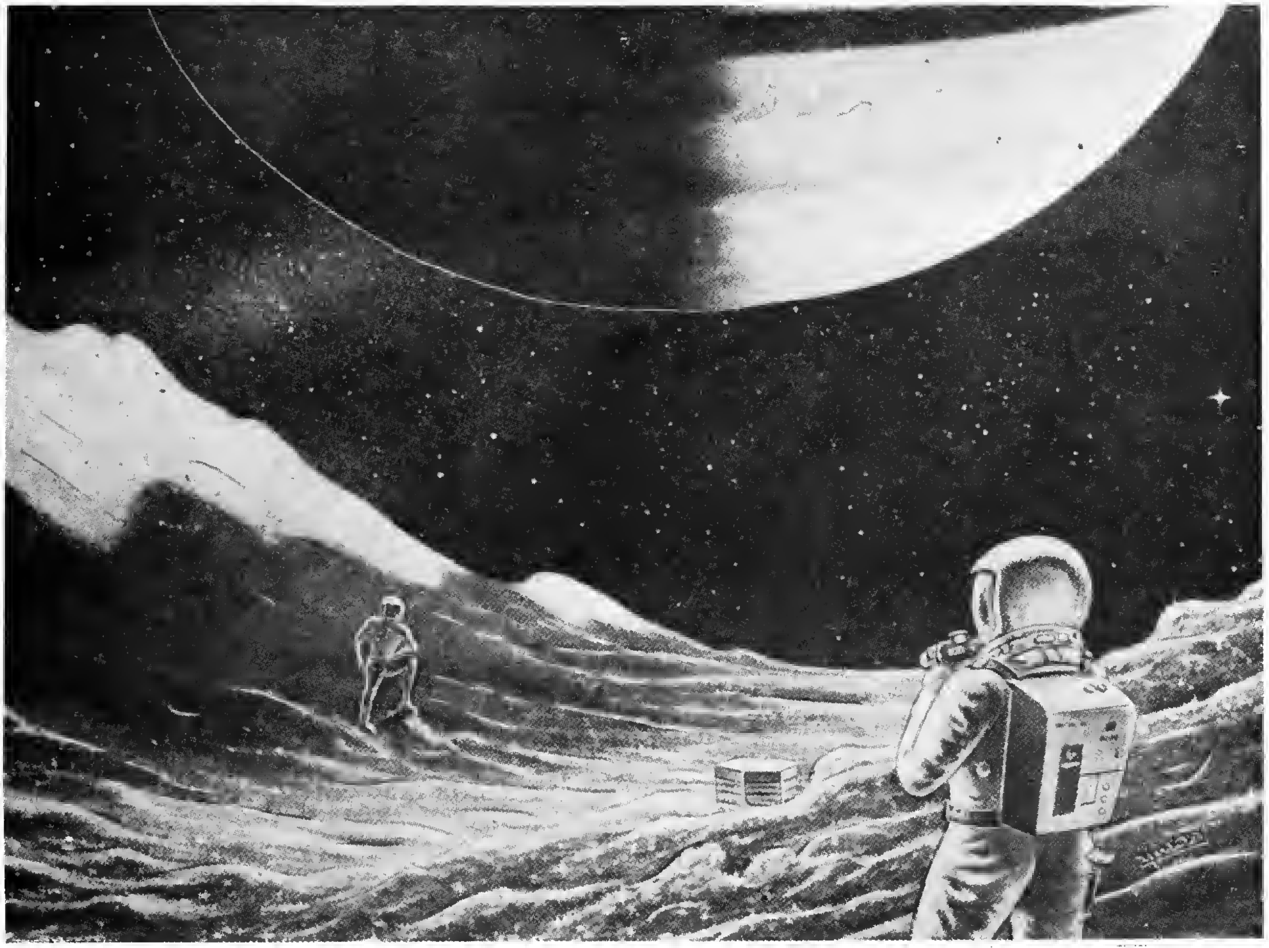
The BIS Daedalus probe is an early attempt at spreading Man's presence throught the Galaxy.
(Painting by Don Dixon, donated by Space Frontiers Ltd*)*

one-millionth of the necessary volume. Orbital space, in other words, is *at least* 99.9999% unexplored for 1 to 10 m objects.

Now consider probes on planetary surfaces. Of the 10^{11} km^2 of Solar System territory outside of Earth, less than 50 million has been examined down to 1 to 10 m resolution. So 99.95% is still virgin territory for this purpose. If objects are buried somewhere or floating in the Jovian atmosphere, there is no chance yet that they could have been found. Even huge 1 to 10 km artificial alien habitats in the Asteroid Belt would be visually indistinguishable from asteroids to terrestrial observers, and the Belt population itself is poorly catalogued.

So it is very unlikely that an extraterrestrial artifact in the Solar System would be seen unless it was deliberately signalling its presence.

Detecting an operating self-replicating machine system is only marginally easier to observe. Likely sites are the Asteroid Belt and the outer Jovian and Saturnian moons. Recent technical studies suggest that individual replicating systems may be 100 m in diameter or less, so a factory system for building probes should not exceed 0.1 to 1 km in size, again well beyond our vision except on the Moon and portions of Mars. Ignition of fusion rockets to propel daughter probes out of the Solar System could be spotted using amateur equipment, but the observation window is very small and of very short duration. Self-reproducing probes should be able to replicate a whole generation in 1000 years or less, and be quickly on their way, so that only mining pits and small debris may remain at this late date.



This painting by David Hardy for the novelette 'Saturn Alia' by Grant Callin in the July 1984 issue of "Analog" deals with the discovery of an alien artifact on the surface of the Saturnian moon Enceladus.

The total mass of probes needed to explore the Galaxy is actually very small. A study by the author showed that a self-reproducing probe, patterned after the Daedalus starship design but capable of entering orbit at its destination, could have a fully-fuelled mass of about 10^{10} kg. If such a device makes 10 replicas during each of 11 generations, that is enough to examine every star in the Galaxy. This takes $10^{11} \times 10^{10}$ kg = 10^{21} kg, or about the mass of Ceres, the largest asteroid. How would we ever know if one Ceres-size asteroid had once been consumed?

More likely, starfarers would require each target star system to supply no more than one new generation of replicants. This is only 10^{11} kg, enough to fill one 1 km crater 40 m deep or to make one 400 m-wide asteroid.

Even more likely, ETI (Extraterrestrial Intelligence) would programme their automata to erect self-replicating probe factories only in uninhabitable star systems and send only non-reproducing exploratory probes here to avoid disturbing any possible inhabitants.

The Artifact Hypothesis

Combing the entire Solar System seems a daunting task, yet radioastronomers remain enthusiastic about the search for extraterrestrial intelligence (SETI) because the seemingly infinite "search space" of the total electromagnetic spectrum can be narrowed considerably by imposing a set of reasonable assumptions on the search. Many quests for interstellar radio beacons and signals have been proposed and actually conducted in recent decades, based on three assumptions:

(1) that advanced ETI exist in the Universe;

(2) that these intelligences are presently attempting to locate, examine or possibly communicate with us;

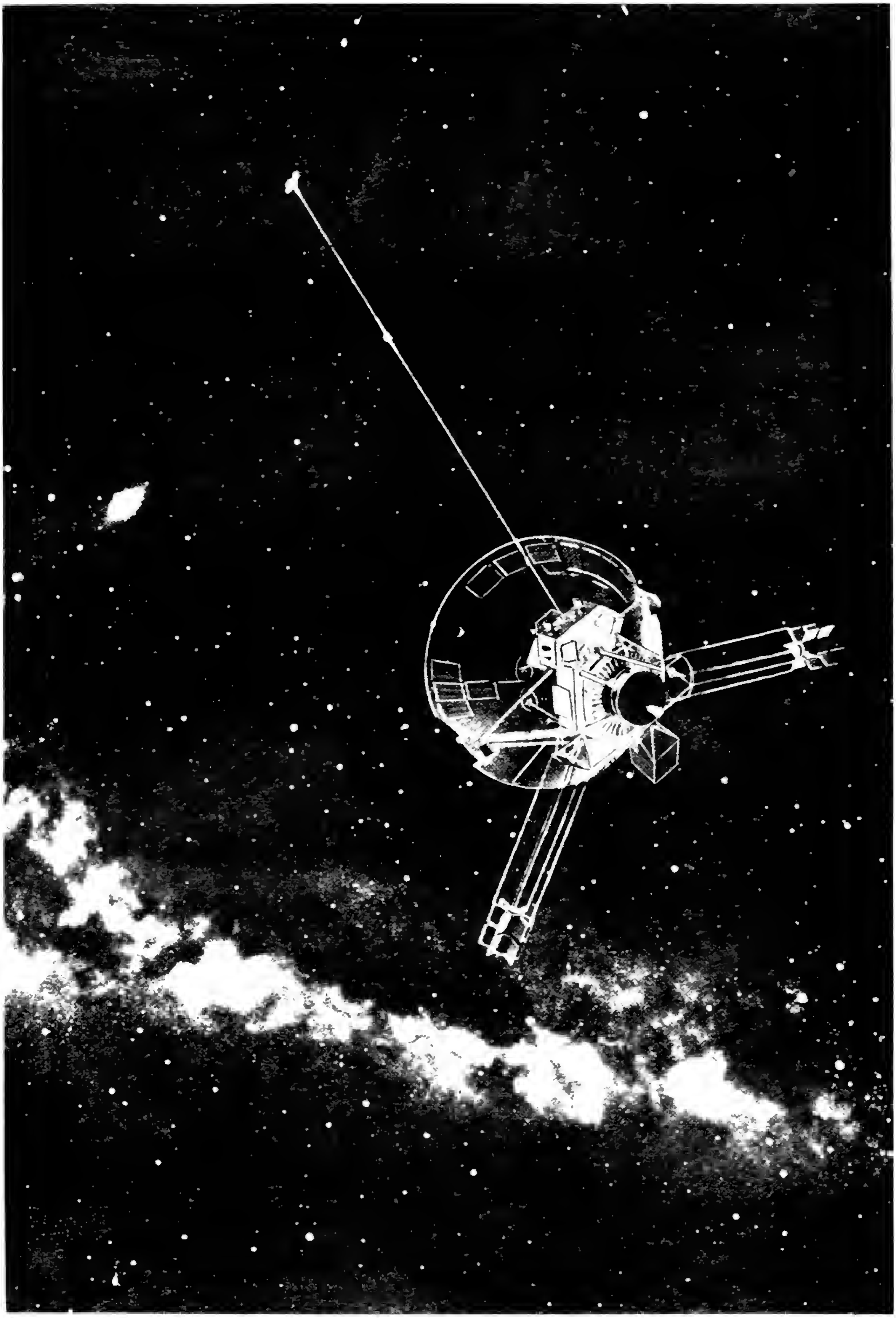
(3) there are unique "magic" frequencies for interstellar communication (e.g. the 'waterhole).

Is it possible to similarly constrain the search space for nearby interstellar probes and artifacts? Start with a fundamental assumption, the 'Artifact Hypothesis':

> A technologically advanced extraterrestrial civilization has undertaken a long-term programme of interstellar exploration via transmission of material artifacts.

Now, if the Artifact Hypothesis is correct and unless the programme has only just begun, some evidence of this extraterrestrial exploratory activity should be apparent within the Solar System. If persistent observation gives no support to the Hypothesis, then the Hypothesis and possibly some of the other most basic assumptions in SETI should be questioned.

Of course, the nature of observable artifacts depends in part upon unknown alien motives for sending them: artifacts not intended for discovery will not be found. For instance, in one scenario the probe imperfectly camouflages itself to test our technology or intelligence level, which test must be passed before communication with the device is permitted. Since the alien engineers are technologically superior, we would not stand a chance of finding their artifact until we meet their (unknown)



conditions. But there are infinitely many possible such "test" conditions. This leads to two conclusions. First, a search for objects not intended to be found is probably fruitless. Second, a failure to find alien objects not intended to be found cannot support or refute the Artifact Hypothesis, so all such observations are a waste.

Similarly, there is no point in looking for artifacts that want to be found – they would already be obvious.

That only leaves artifacts with a "neutral" attitude – those that do not care about outsiders. The search for "neutral" artifacts provides an excellent observational opportunity because the search can be confined to those places where probes are most likely to be stationed solely for scientific expediency. Our search can therefore be defined in terms of objective criteria: the site would have been chosen strictly for reasons of efficiency, maintainability, high research payoff and low environmental risk.

Where To Look?

An active alien exploratory probe capable of self-repair would stake its claim to the best possible location for monitoring phenomena relevant to its mission of seeking out life and intelligent species. To maximise the efficient use of resources, alien engineers would have designed it to be as simple as possible yet still be successful. Artifacts must likely satisfy two critera:

Criterion I. Ability to consistently monitor environments most likely to harbour or evolve intelligent life.

Criterion II. Maximum artifact lifespan with minimum complexity.

The only place that life has existed for aeons, it appears, is the Earth, clearly the most exotic place in this Solar System. Earth is the principal target for continuous surveillance and a superbly-crafted intelligent probe must be expected to understand this. Criterion I thus requires the artifact to be sited either in orbit near Earth or the Moon, or in an orbit that frequently carries it close enough to Earth to permit adequate periodic surveillance. Terrestrial surface sites are unlikely because these would restrict the ability of the probe to continuously monitor the entire environment. Even if the main probe were not situated near Earth, it would likely deploy permanent surveillance subprobes in the vicinity which would themselves be detectable. In the lexicon of radio-SETI, circumterrestrial space is a "waterhole" region where extraterrestrial probes may be expected to congregate, seeking life and intelligence.

Criterion II (maximum lifespan) implies that it would attempt to spend as much time as possible in regions of low environmental hazard. It will seek out locales with minimum high-energy particle intensities and electric and magnetic field densities and minimum danger from micrometeorite and debris impacts. This rules out planetary magnetospheres and ring systems.

Also, to maximise lifespan, the artifact must have access to sufficient energy. Self-contained systems are unlikely to provide enough power for data processing, self-repair operations, orbit/attitude control and interstellar radio transmission. An onboard fusion power plant is possible, but most likely the artifact will collect solar energy. This requirement, plus Criterion I, eliminates all outer planet sites.

Finally, to minimise probe complexity, orbits must be dynamically stable over long periods of time – this eliminates most heliocentric orbits. Criterion II also argues strongly against siting the artifact on the surface of any celestial body having

a. an appreciable escape velocity requiring a major propulsion system for deorbit or ascent,

b. an appreciable atmosphere requiring complex additional maintenance systems for continuous protection from degradative chemical, biological, thermal, erosional, hydrological, climatic and geological events, or

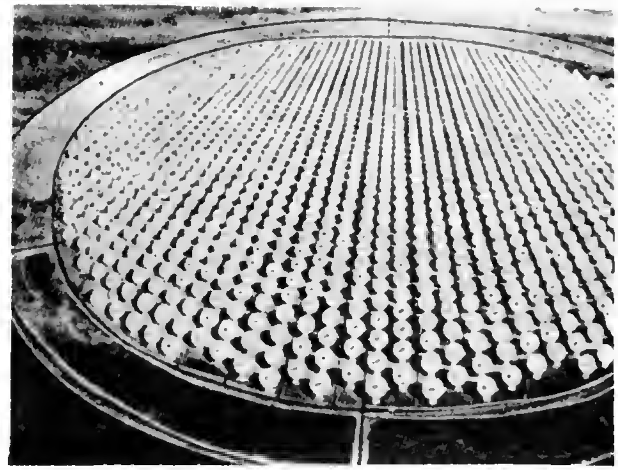
c. rotation, clouds and electromagnetic phenomena that might inhibit continuous access to solar energy and which may interfere with its ability to observe or to transmit progress reports.

The potential search volume thus reduces to five distinct orbital classes (all of which are poorly studied for 1-10 m objects):

1. Geocentric orbits between two Earth-centred concentric spheres of radii 70,000 and 326,400 km;
2. selenocentric orbits between 3000 and 58,100 km lunar altitude;
3. stable synodic libration orbits around Earth-Moon Lagrangian points L4 and L5;
4. Earth-Moon halo orbits near collinear Lagrangian points L1 and L2; and
5. Sun-Earth L4/L5 Lagrangian orbits.

These "magic orbits" are the targets at which a preliminary SETA programme – the Search for Extraterrestrial Artifacts – should take aim.

Opposite page: The Pionaer 10 probe carrias a plaqua that may ona day tall an alien intalligance of its origin as it voyagas batwean tha stars. *NASA*



The 1971 Cyclops concept would have used a large array of antennae for SETI.

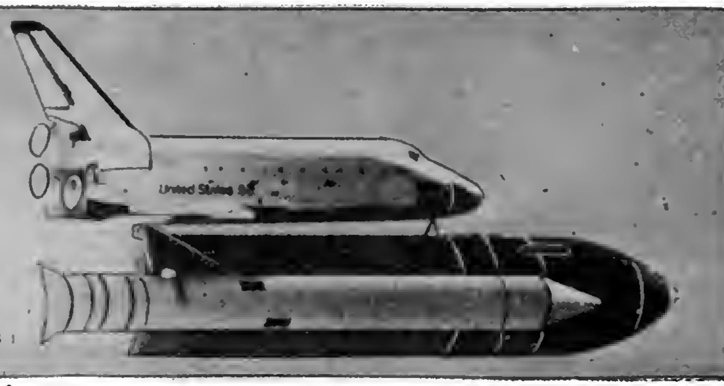
NOTES & REFERENCES

For SETA theory, see the author's: "The Case for Interstellar Probes," *JBIS* **36** (November 1983): 490-495; "Extraterrestrial Intelligence in the Solar System: Resolving the Fermi Paradox," *JBIS* **36** (November 1983): 496-500; "The Search for Extraterrestrial Artifacts (SETA)," *JBIS* **36** (November 1983): 501-506; and "If They are Here, Where Are They?" *Icarus* **55** (1983): 337-343.

The author and Francisco Valdes have made the first searches for extraterrestrial artifacts. See R.A. Freitas and F. Valdes, "A Search for Natural or Artificial Objects Located at the Earth-Moon Libration Points," *Icarus* **42** (1980): 442-447; and F. Valdes and R.A. Freitas, "A Search for Objects Near the Earth-Moon Lagrangian Points," *Icarus* **53** (1983): 453-457.

SPACE REPORT

A monthly review of space news and events



SPACE SHUTTLE

INDIAN FOR SHUTTLE

India has accepted NASA's offer to fly an Indian payload specialist aboard the Shuttle with the Insat-1C satellite in 1986. The astronaut will be an engineer or scientist from the Indian Space Research Organisation (ISRO). The two organisations will work together to identify joint experiments that might be performed aboard the Shuttle. According to NASA's launch manifest of August 1984, Insat will be aboard the same flight as Britain's Skynet 4B military communications satellite, possibly accompanied by a UK astronaut.

The first Indian in space, Rakesh Sharma, flew in April 1984 to the Salyut 7 space station. India will thus become the second nation, following France, to fly astronauts under both the US and Soviet programmes.

SHUTTLE PACIFIC EMERGENCIES

NASA and the French space agency have agreed to provide an emergency recovery facility for the Shuttle in the South Pacific. NASA Administrator James Beggs and the Director-General of the French Centre National D'Etudes Spatiales (CNES), Frederic D'Allest, have signed an interagency arrangement relating to emergency support for the Space Shuttle.

Under the arrangement, which lasts for 10 years, France has agreed to assist NASA in the event of problems during launches from the Western Space and Missile Center on the coast of California (which are scheduled to begin next October). About two to three launches are expected per year once the facility is fully operational. Such assistance would include permission for emergency landing in French Polynesia as well as steps necessary for recovery and return of the vehicle to the US.

SHUTTLE TRANSFER STAGE

The Astrotech International Corp. has authorised McDonnell Douglas to begin work on the design and development of the Delta Transfer Stage (DTS), writes Nicholas Steggall. This new commercial Shuttle upper stage is intended to place satellites into geostationary orbit.

Essentially, it is a modification of the second stage of the Delta expendable launcher. Although the liquid propellant DTS calls for the redesigning of this Delta stage to fit into the Shuttle cargo bay, it is basically a reconfiguration of current flight-proven systems.

Its performance capability will be in the range of 1300 kg to 9100 kg to geostationary transfer orbit, with up to 4100 kg arriving in geostationary orbit. DTS also has a multiple payload capability, allowing independent spacecraft separation and precise orbit insertion.

IUS READY FOR FLIGHT

Data from a critical motor test on 29 August indicates that problems with the Inertial Upper Stage (IUS) have been overcome and it is ready for flight. The first Shuttle-launched IUS failed during the STS-6 mission in April 1983 while it was carrying the TDRS communications satellite. A seal failed on the second stage because of heat from the burning solid-propellant motor and steering was lost.

The static 112 seconds test at the US Air Force's Arnold Engineering Development Center in Tennessee was the third in a series of firings designed to prove the modified version. The 'techroll' seal that failed is made of two layers of Kevlar fabric covered by neoprene rubber and is filled with silicone oil that allows a low-friction rolling contact with the nozzle housing as the nozzle is gimballed.

During the STS-6 flight, 83 seconds into what was to have been a 107 s firing of the second stage motor, the techroll seal collapsed because of overheating, caused by hot gases leaking through the nozzle thermal protection system.

Several changes to the nozzle design were made to ensure that this problem will not occur again, including the thickening of the nozzle nosecap and the addition of insulation around the techroll seal.

SSME TEST

The 800th single engine test of a Space Shuttle Main Engine was conducted recently at NASA's National Space Technology Laboratories facility, writes Nicholas Steggall. Engine 0207 was fired for 100 seconds (bringing its own time to 2198 seconds) and increased the total number of seconds to 144,530 in the SSME test programme.

Boyce Mix, SSME programme resident manager, said that the "testing of engine 0207 continues to add to the development of upgraded high-pressure turbopumps." Test firings of engine 2014 were also underway to qualify hardware that will be installed later on flight versions. A high-pressure fuel pump was used in *Challenger* during the 41G mission in October.

SRB CONTRACT

NASA has selected United Space Boosters for negotiations leeding to a five-year contract to menufacture, assemble and refurbish 84 flight sets of solid rocket boosters for the Spece Shuttle.

Under a seperate contrect, USBI will build e new fecility et NASA's Kennedy Space Center for booster assembly and refurbishment. In the pest, refurbishment has taken plece et Kennedy's Vehicle Assembly Building - used to assemble the entire configuration of orbiter, boosters and external tenk.

SPACE STATION PROPOSALS

NASA issued e Request for Proposel to US industry on 14 September for the definition and preliminery design of e permanently manned Space Station to be operetional in low Earth orbit early in the 1990's. Responses were due in by 15 November.

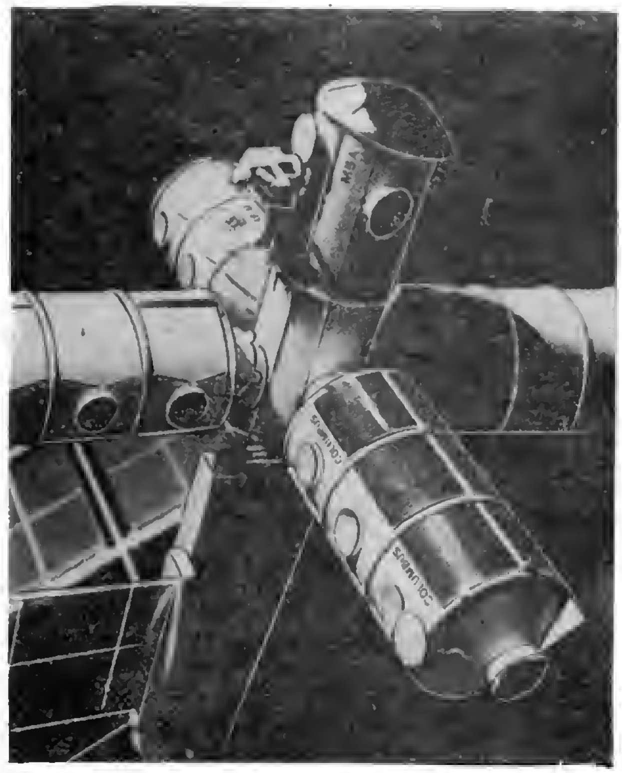
The request contains four 'work packeges' covering definition and preliminary design (Phase B) of Spece Station elements. NASA plans to ewerd competing contracts for each of the work packages and hes scheduled 1 April 1985 as the terget dete.

In eddition to the study of the permenently manned system, the Request for Proposal elso requires contractors to study how those elements of the Space Station would change were the stetion initially man-tended rether than permanently menned. Contractors will also be expected to pay particular attention to recommendetions of the NASA Advanced Technology Advisory Committee, which is identifying automation end robotic technologies thet could be used in the Space Station.

Following completion of the 18-month definition and preliminary design contracts, NASA intends to move in 1987 into final design and development. Beceuse of the long lifetime of the Station and its evolutionary growth and internationel participation, there will be no single prime contrector. Instead, the overall system engineering and integration will be performed by NASA's Johnson Space Center.

Other NASA centres are responsible for:

Three Canadian astronauts ara expected to fly over the next 18 montha. Marc Garnaau (right, sitting) flaw aboard Mission 41G in October; Bob Thirsk (laft, sitting) waa his backup. Tha two other flight payload specialists will be selected about a yaar befora their flighta in early and mid 1986. Tha taam ia, from laft, Kan Monay, Bob Thirsk, Roberta Bondar, Stava MacLaan, Bjarni Tryggvason and Marc Garnaau.



MBB-ERNO and Aarotalia have jointly davaloped tha 'Columbus' concept based on Spacalab modulas. It could provida Europe with an independant free-flying orbital base or be part of the US Space Station.

- Work Package One, Marshall Space Flight Center. Definition and preliminary design of pressurised common modules with appropriate systems for use es leboretories, living ereas and logistic trensport; environmental control and propulsive systems; plen for equipping a module as a laboratory and additionel ones es logistics modules; and plan accommodetions for orbital manoeuvring and orbital transfer vehicles.
- Work Package Two, Johnson Space Center. Definition and preliminary design of the structure framework to which the various elements of the Spece Station will be etteched; interface between the Spece Station end the Spece Shuttle; mechanisms such es the Remote Menipulator Systems; attitude control, thermal control, communications and data management systems; plan for equipping a module with sleeping quarters, wardroom and galley; and plan for extravehicular activity.
- Work Peckage Three, Goddard Space Flight Center. Definition and preliminary design of the eutometed free-flying platforms and of provisions to service, meintain end repair the platforms and other free-flying spacecraft; provisions for instruments and payloads to be attached externally to the Space Station; and plan for equipping a module as a laboratory.
- Work Package Four, Lewis Research Center. Definition and preliminary design of the electrical power generation, conditioning and storage systems.

As pert of the overell programme, two or more unmanned free-flying pletforms will be developed for use with the Space Stetion. A meximum of common subsystems such as power, thermal, docking, data, etc,

will be used on both the Station and the platforms. The platforms will be tended and services by the Station in orbit and they will be able to be released and serviced by the Shuttle in high inclination or polar orbits.

NASA's plans call for an initial Space Station to be operational in the early 1990's. It will be able to grow both in size and capability and is intended to operate for several decades, well into the 21st century. It will be placed in a low Earth orbit about 500 km high and at an inclination to the equator of 28.50°. It will include a number of pressurised modules and a power supply of 75 kW, support a crew of six to eight people and have two or more free-flying unmanned platforms.

For the purposes of the Request, NASA has selected a reference configuration called the power tower, one of a family that uses similar elements or components. The power tower family is considered a starting point for definition studies but is expected to undergo significant modifications as the studies progress. Contractors may offer modifications within this or other preliminary designs.

SATELLITES

GMS-3 LAUNCHED

Although delayed two days due to a typhoon, Japan's third weather satellite, GMS-3, was launched by an N-2 vehicle on 3 August 1984 from the Tanegashima Space Center, writes Nicholas Steggall.

On 4 August, the apogee motor fired on command from the Katsuura Tracking and Data Acquisition Station to inject GMS-3 into the intended drift orbit to reach its final orbital station at 140° E longitude. Although the satellite was correctly positioned over the equator there is some concern that it may experience the same problems that affected the first two models. Both GMS-1 and GMS-2 had trouble with their scan mirrors and similar problems have occurred on the American GOES.

INSAT-1B ANNIVERSARY

The Insat-1B satellite completed one year in space on 31 August 1984, writes Nicholas Steggall. It was launched by Shuttle *Challenger* on the STS-8 mission in 1983 and has been providing voice and data communications, weather forecasting services and direct broadcast TV for India.

In a letter to Ford Aerospace in the US (Insat's builders) from the Indian prime minster, Mrs Indira Gandhi, it was noted that "Insat... indicates that developing countries can face the risks of innovation in the aplication of advanced technology to solve Earthbound problems. They need not always follow the well-trodden pathways which are thought to be risk free. This is an important example of international cooperation."

GEOS 2 REACTIVATED

At the request of Switzerland and Germany, ESA reactivated its Geos 2 spacecraft in September. The satellite was launched into geostationary orbit in June 1978 to investigate the magnetosphere and completed its planned scientific mission in July 1980.

In response to the continued interest shown by the scientific community, Geos 2 operations were resumed in 1981 and continued until the end of 1983. The last year of this extension was carried out as a special project financed by Germany and Switzerland. In January 1984 it was moved from the densely-occupied geostationary orbit into a higher and slightly asynchronous path where it now drifts at a rate of about 3.5° in longitude per day, becoming visible to the ground station at Michelstadt in West Germany for four weeks every 3½ months. The new data will be helpful in support of the three-satellite AMPTE project presently patrolling the fringes of the magnetosphere. Geos 2 has proved to be very useful as the reference spacecraft for the International Magnetosphere Study. It has collected good quality magnetic attitude data and the observations carried out near the geomagnetic equator have proved particularly interesting. The information has been widely used in correlations with ground-based data and also with data from other satellites. It has made a significant contribution towards identifying the composition and movement of the plasma around the Earth's magnetosphere.

ASTRONOMY

NEW EXPLORER UNDERWAY

NASA has started work on the Extreme Ultraviolet Explorer (EUVE), a new astronomy satellite that will be launched into Earth orbit from the Shuttle in 1988. The primary aim is to make the first all-sky map in the extreme ultraviolet (EUV) band of the electromagnetic spectrum, between ultraviolet and X-ray light.

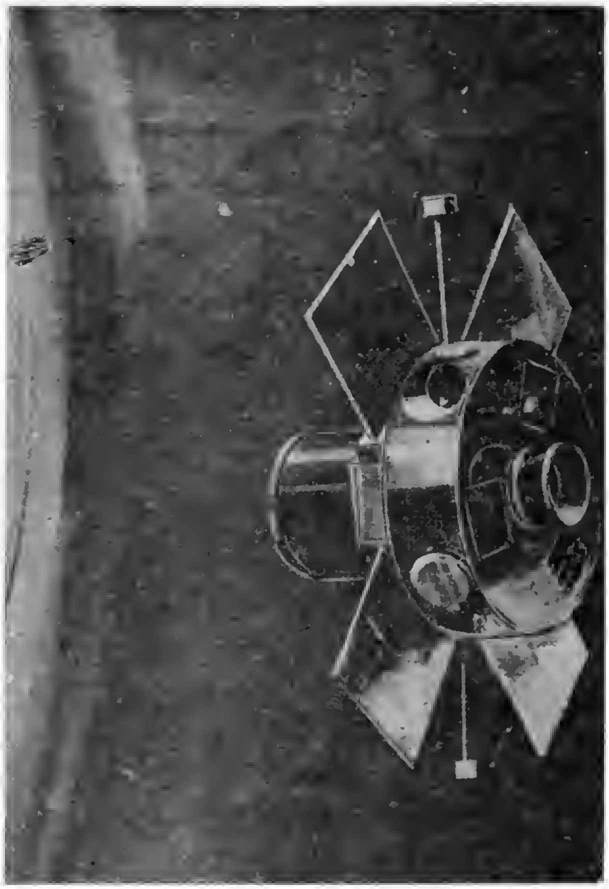
EUVE will be a true explorer in that it will conduct the first in-depth investigation of this critical and interesting band. The observations are expected to discover stars and other celestial objects with unexpected characteristics, as was done by the Infrared Astronomical Satellite in 1983 and by other spacecraft during their initial all-sky surveys in other spectral bands.

EUVE will orbit at an altitude of 550 km. From this vantage point above the atmosphere, instruments can scan the sky for radiation that cannot penetrate the Earth's atmosphere and is therefore invisible to observers on the ground. It will use four 40 cm telescopes to conduct the all-sky survey and a spectrometer to make detailed observations of the new sources.

EUV astronomy is a relatively new field; observations from sounding rockets and satellites have found only 10 such cosmic sources to date. This sparse mapping is in stark contrast to the thousands of X-ray and infrared sources and millions of optical objects that astronomers have catalogued. Orbital surveys, similar to that planned for EUVE, are the first major steps in producing scientific results from an unexplored wavelength band. The surveys inevitably produce important discoveries.

EUVE is expected to help astronomers unravel and understand several aspects of the nature and evolution of stars. Most stars, for example, the Sun included, are known to have hot gaseous coronae surrounding them. However, the processes that give rise to these coronae are not well known. Through observations from EUVE's instruments, astronomers will be able to study directly, for the first time, the emissions of stellar flares and coronae in the extreme ultraviolet. Similar observations of our Sun are being carried out by the Solar Maximum Mission spacecraft which was repaired in orbit by Shuttle astronauts earlier this year. Solar max is not sensitive enough to carry out studies of other, much fainter, stars.

EUVE will also gather data on hot white dwarf stars.



These stars, which have exhausted their nuclear fuel, emit extreme ultraviolet as they cool. In addition, it will perform studies of the local interstellar gas within a few hundred light years of the Sun. Since the clouds of this gas absorb extreme ultraviolet radiation, it will be possible to map their presence by observing the emissions of EUV stars behind these clouds.

SPACE VEHICLES

BRITISH UPPER STAGE

With the increasing mass of satellites there is a growing need for a reliable, high-performance stage to move items from the Shuttle orbit to geosynchronous transfer orbit. Satellites from 1800 to 3600 kg are to be expected. To meet this need, Scott Science and Technology Inc., a US corporation headed by ex-astronaut David Scott, has placed a contract with British Aerospace to design such a vehicle using a liquid-fuelled engine like Aerojet's Transtar.

The 'Satellite Transfer Vehicle' will use non-methyl hydrazine as fuel, with nitrogen tetroxide as oxidiser, to feed the engine. The engine, tanks and fuel control system will be housed in a cylindrical body 2 m long, which will also carry a five-point mounting system for the Shuttle and a three-axis control system and autonomous power and guidance systems if required. The body is designed for release by standard Shuttle mechanisms and for handling by RMS robot arms.

Using a liquid propellant engine allows a choice of burn strategies for different missions, ranging from single burn to apogee transfer, or multi-burn in which the satellite is lifted to geosynchronous altitude in more than one phase. Reaction control will use a cold gas system for safety when it is near the Shuttle.

Two satellites with a total mass of up to 3600 kg could be launched in tandem by using a split shroud, one spacecraft being contained within the shroud and the other on it. At apogee, the outer satellite would separate first.

EXPENDABLE BOOSTERS

The US Air Force project to acquire a new expendable space booster gained more support from a committee of the National Research Council, part of the National Academy of Sciences. A report, requested by Congress and published on 28 August, said that the proposed rocket offers more flexibility and security advantages than the Shuttle. Any of three boosters under study could do the job for about $10,000 million and take 10 missions away from the Shuttle.

There are several alternatives: Atlas II Centaur, Titan 34D7 and SRB-X (solid rockets) would offer as much payload capability, 30,000 kg, as the Shuttle. All three would use the high energy Centaur upper stage now under development for Shuttle missions. None of the three, however, offers any growth potential. The committee urged the government to plan another generation of launch vehicles with greater lift capability. The report estimated future payloads could approach 90,000 kg, which reminded observers of the defunct Saturn 5 that lifted 150 tonnes to orbit. None of the NASA Orbiters has yet lifted 30,000 kg of payload.

NASA is concerned because it anticipated that Dept. of Defense missions would account for up to one third of future Shuttle flights. Less military usage would increase costs to private customers.

OTHER NEWS

PLASMA PHYSICS

Three rockets were launched successfully in late August from NASA's Wallops Island site in Virginia to conduct wave/plasma experiments and to compare measurements and techniques for studying electric fields in the Earth's upper atmosphere.

The specific object was to study interactions in the magnetosphere by injecting coded VLF (Very Low Frequency) radio waves from a transmitter in Annapolis, Maryland, operated by the US Navy. Scientists are attempting to understand 'electron precipitation' induced by the radio waves, detecting it from the X-rays produced when the atomic particles collide with the atmosphere. This experiment on the Nike-Orion sounding rocket was coordinated with the Japanese Exos-C satellite flying overhead to provide *in situ* measurements.

The electric field study was designed to measure, simultaneously, atmospheric electric fields and other relevant parameters that can cause variations in these fields. This will help to develop our understanding of the coupling between the upper and lower atmospheric electrical environment, which includes the electric fields in the ionosphere and those related to thunderstorms.

The Super Loki Datasonde, a small meteorological rocket, collected meteorological information in the Earth's middle atmosphere for correlation with the scientific experiment. The experiment packages launched by the Nike-Orion and Orion rockets were successfully recovered in mid-air by the Wallops Skyvan aircraft. They will be flown on future research missions.

THE FIERY REENTRY OF ET-41C

By Paul Maley

The beautiful Pacific islands of the Hawaiian chain formed the backdrop for two extraordinary visual events in the spring of 1984. One of the world's largest active volcanoes suddenly roared to life, spewing ash, steam and dust into the air for weeks but the second, even more spectacular, was the fiery reentry of the Shuttle mission 41C's external fuel tank, creating a fireball estimated to exceed magnitude -8! The author, from the Johnson Space Center Astronomical Society, describes the event.

Introduction

The eruption of 4300 m high Mauna Loa began early in the morning of 24 March and was spotted by astronomers on neighbouring Mauna Kea, the twin volcanic peak where a number of large astronomical instruments are based. At the same time, I was preparing to observe the External Tank reentry of 6 April, which was deliberately planned so that dynamics and dispersion observations could be made by NASA. With preliminary knowledge of the trajectory and plans for the release and reentry of the 47 m long, 8.5 m diameter propellant tank, it was possible that a night reentry could be photographed against the silhouette of the Mauna Loa outburst. It was always possible that the Shuttle 41C launch would be delayed for a mechanical problem and the planned trajectory showed that the tank would become visible at a very low angle above the horizon from Hawaii just 50 minutes before sunrise. Not only were the viewing circumstances rather marginal but any slight deviation from the flight path could cause the observation plan to go awry.

Further iterations on the trajectory were done at NASA's Johnson Space Center in Texas: maximum elevation above the local horizon would not rise above 9° at best. However, given the dark sky, conditions at a site as high as the Mauna Kea observatories might gain a couple of degrees by *looking down* at the horizon. Another problem was the heavy smoke from the forest fires generated by the advancing lava flows.

The portable video set up.

Reentry video of fragments; notice the contrails.

The Reentry

The External Tank is the tallest part of the Shuttle. Normally it is jettisoned about eight minutes after launch to fall harmlessly into the Indian Ocean. Two previous reentries were witnessed at long range by South African commercial airline pilots and some hand-held 35 mm photographs of poor quality were taken.

Some future Shuttle launches will be made from California into polar orbits on what are termed 'direct insertion' trajectories. Rather than the Shuttle being boosted into higher and higher orbits by a series of engine burns, the intent is to go directly into the final orbital altitude from launch. In this situation, the tank will be carried farther than usual. NASA thus planned to study a reentry of the new lightweight (30,000 kg) tank to better understand its aerodynamics, including monitoring of surviving fragments and their trajectory dispersion along the track and sideways and the mechanism necessary to control the stability and tumble rate of this flying space cylinder.

The size of the reentry 'footprint' has a bearing on the orbit apogee and the Shuttle's payload capacity. Since the footprint is a very large zone to allow for major errors in dispersion, the impact of tank pieces should come no closer than 370 km to the nearest land mass. Such planning should also keep it out of foreign air space as it begins the burn-up process and it should steer clear of such diverse spots as offshore oil platforms and drilling rigs. The polar regions should also be free of any debris.

Making the Observations

NASA uses sophisticated radar and optical tracking devices to follow the progress of reentries but, since most of these stations are fixed and some have problems viewing at low angles, it occurred to me that a portable amateur system might be able to provide valuable supplemental data. The major advantage is the ability to avoid bad weather systems.

Two methods of data recording were considered. The first involved a low-light-level video camera coupled to a relay lens and image intensifier. A 100 mm Nikon objective camera lens focused on to the intensifier which compressed the image onto the relay lens then on to the video electronics. The final image would appear on a black and white battery-powered monitor. Simultaneously, the output of the surveillance camera would feed into a General Electric portable video cassette recorder on VHS format tape. The camera and recorder would be powered from rechargeable Nickel Cadmium batteries while the intensifier tube operated from two penlight cells. The optical system was arranged on a horizontal bar which

SPARTAN: SPACE AT LOW-COST

By the Staff of NASA

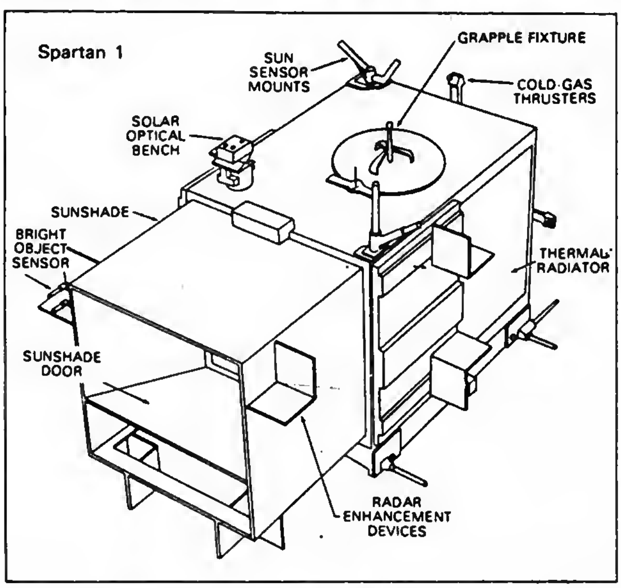
For more than 20 years, NASA has been using sounding rockets to carry instruments into the upper atmosphere and nearby outer space. They were originally built with surplus military hardware and later evolved into a special class of vehicles specifically built for space research. Similar, relatively inexpensive, experiments can now be carried by 'Spartan' aboard the Shuttle.

Introduction

Sounding rockets continue to be an essential tool for obtaining quick and reliable information on aurorae and the upper atmosphere. The instruments provide data on ionization, temperature, wind, air density and chemical composition. In addition, rockets have become a tool for astrophysics and solar physics, carrying telescopes and cameras above the obscuring effects of the Earth's atmosphere. Since the flight of a sounding rocket is limited to a few minutes, what it can achieve is also limited. Instruments developed for the study of high-energy astrophysics, solar physics and ultraviolet astronomy, for example, can benefit from much longer observation periods.

The opportunity now exists to take sounding rocket-type experiments into Earth orbit *via* the Space Shuttle. Spartan is replacing the sounding rocket as the carrier and can accommodate existing types of scientific instruments. Spartan 1 is ready to fly now - it was displaced from Shuttle 41F only because of the 41D launch delays.

Spartan rides into space attached to a support structure in the cargo bay, waiting to be released with the robot arm to fly independently of the Orbiter. This autonomy allows the scientist to operate his instrument precisely without any demands on the Shuttle crew or the craft's attitude. He can preplan a pointing sequence for an extensive selection of celestial objects or a particular area of the solar surface which will be performed by Spartan to minutes of arc precision. The observations are automatically stored on board the carrier on a tape recorder.



Spartan 1, which will study cosmic X-ray emissions, is scheduled for launch aboard Shuttle 51C next May. *NASA*

After flying separately for up to 40 hours, Spartan is retrieved by the Shuttle and returned to Earth. The recorded data are then copied and sent to the scientist for analysis.

Future Spartans will have greater abilities, evolving in a manner similar to sounding rockets. "Man in the Loop," additional power, extended mission time, greater pointing accuracy, increased data handling and command capability are possible improvements.

Spartan: Simplicity

The Spartan Program follows the same fundamental philosophy as the sounding rocket programme: keep it simple; keep the cost down. NASA engineers have found that since rocket flights are short and vehicles are inexpensive, it is more efficient and cost-effective to build simple, nonredundant systems and make them work for the duration of the flight. This philosophy has demonstrated an 85% success rate in rocket flights. Furthermore, the design, test and documentation requirements for Spartan are modest when compared to the requirements for major satellite missions.

As a carrier, Spartan is designed to provide the barest essentials needed to operate the instrument, such as battery power, stellar pointing and data recording. NASA is designing Spartan to use attitude control systems, data encoding systems, batteries, timers and other control hardware that have been developed and flight proven as part of the sounding rocket programme. However, there are differences: both thermal control and more sophisticated automation are necessary for the longer flights.

The time available for observation is an increase of 100 to 1000 times over that of sounding rockets - battery power and gas for the attitude control system are the major limitations. Spartan records all data on a large-capacity, onboard tape recorder and makes up for the lack of a command link by using a microprocessor-based programmed controller. It is efficient but not elaborate.

Scientists using Spartan will find the carrier to be flexible in accommodating instruments required for specific investigations. The initial instruments scheduled for the early Spartan missions will study high-energy astrophysics processes, solar physics phenomena and ultraviolet astronomy. Each instrument has a successful record on sounding rocket missions but each has unique requirements. The high-energy astrophysicists need large-

area array detectors, the ultraviolet astronomers need telescopes and both require stellar pointing. The solar physicists use telescopes and thus need solar pointing. The basic Spartan concept has been adepted to satisfy these initial requirements.

Spartan 1: High Energy Astrophysics

Brilliant and turbulent clusters of galaxies exist throughout the Universe, emitting energy over a wide portion of the electromagnetic spectrum. A very importent part emerges as X-rays, which originate in a hot gas pervading the cluster and sometimes the interiors of the galaxies themselves. Astronomers studying cosmic X-ray sources have detected clusters that are millions of light years away. Although many other X-rey sources (including pulsars and black holes) have been identified over the past two decades, clusters of galaxies hold special fascination.

Astronomers ponder the development and distribution of galaxies in the Universe. Are all galaxies uniform in chemical composition? What is the source of the very intense high-energy emission observed at the centre of some galaxies? Is there sufficient matter present in the hot gas to bind the cluster together? The X-rays are the key to understanding the structure, temperature, composition, dynamics and evolution of clusters.

Spartan 1 was designed specifically to provide astronomers with the opportunity to map X-rays emanating from clusters of galaxies and to explore the centre of our own. The payload consists of a Naval Research Laboratory instrument containing two large X-rey counters equipped with collimators to define the direction of the X-ray sources. This type of instrument has previously provided brief 'snapshots' of X-ray sources from sounding rockets.

Spartan 1 points the instrument with the stellar attitude control system so that it can scan the sources systematically and allow the construction of a two-dimensional picture of the emission. Thus, clusters will be mapped and data will be gathered on the temperature of the intracluster gas and on galactic evolution.

Since the carrier has a modular design, the X-ray detectors can be repleced with others for future missions.

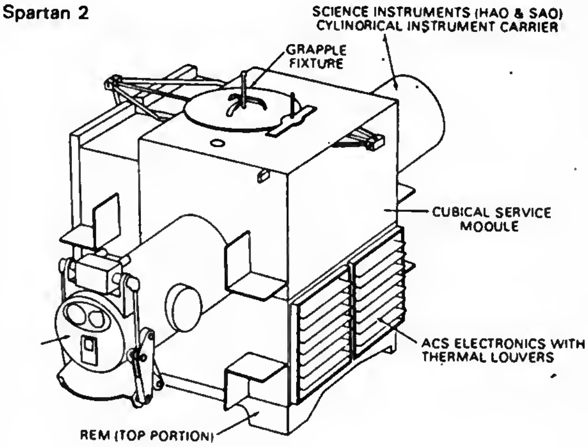
Spartan 2: Soler Physics

The solar wind accelerates electrons, protons and heavy ions out into space from the outer atmosphere of the Sun. The forces behind the solar wind are presently thought to be "non-thermal;" that is, the wind is driven by hydrodynamic waves, electrical currents or some other process. Solar physicists are attempting to define these forces in order to identify the energy transfer processes within the Sun.

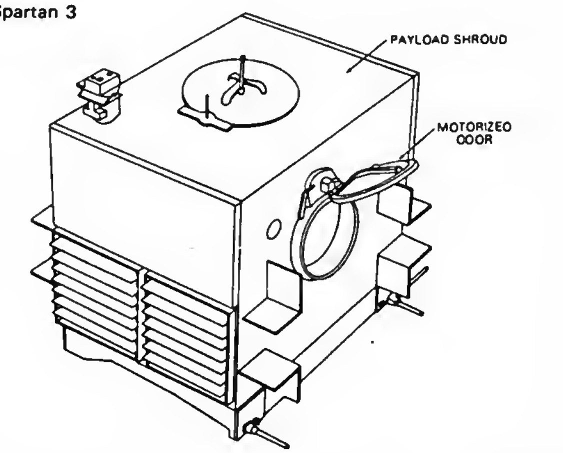
Spartan 2 will probe the acceleration of the solar wind. Temperature profiles for hydrogen gas, hydrogen ions, and electrons will be gathered; the densities of hydrogen ions and electrons will be determined. The results should suggest solutions to the most perplexing questions of coronal and solar wind physics with dramatic observations.

The payload is a 43 cm diemeter solar telescope derived from a sounding rocket solar telescope. It includes ultraviolet and white-light coronographs to measure the intensity and scattering properties of solar light. Spartan 2 will provide solar pointing and thermal control to protect the instruments from the heat of the Sun. Future missions can reuse the vehicle.

Spartan 2



Spartan 3



Spartan 1: The High-Energy Astrophysics Spartan will provide a structure with an optical bench to accommodate a variety of rectangular array detectors. It is designed to point at stellar objects.

Spartan 2: The Solar Physics Spartan will accommodate a 43 cm diameter telescope. It will use fine-pointing to view selected points on the solar surface.

Spartan 3: The Ultraviolet Astronomy Spartan will use concepts and hardware developed for the first two Spartans. It will carry a 55 cm stellar telescope externally similar to the telescope of Spartan 2 and use a stellar fine-pointing system similar to that developed for Spartan 1.

Spertan 3: Ultraviolet Astronomy

The Universe as seen in the fer ultraviolet is rich in phenomena and information. Vast and mysterious nebulae glow intensely in the far UV. Young stars, white dwarfs and hot subdwarfs release far-UV signatures that narrate their fates. Far UV radiation, curiously, permeates the entire background of space. However, much of the UV reaching the Earth is absorbed in the upper atmosphere, making ground-based observations impossible.

Spartan 3 will offer the opportunity to conduct a far-ultraviolet survey of selected star fields in 1987. The positions and far-UV brightnesses of stars will be obtained and images of nebulae and nearby external galaxies, such as the Magellanic Clouds and the Andromeda Galaxy, will be captured. The radiation intensity and spectral absorption/reflection data will indicate composition, temperature and dynamics of far-UV sources.

The Spertan 3 payloed will be a Mark-II Schmidt electrographic camera which images in the 1230 to 1600 Å renge; it has been flown successfully on sounding rockets.

THE UPPER ATMOSPHERE RESEARCH SATELLITE

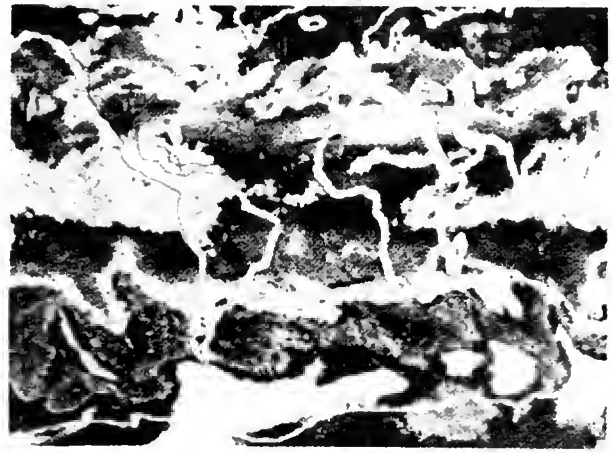
By. Dr. Fredric Taylor

The Earth's atmosphere has now been under study from space for many years. Yet there is still much that we have to learn. The author, a Principal Investigator on the Upper Atmosphere Research Satellite, describes how this new-generation satellite will add to our knowledge.

Introduction

In recent years mankind has gone from taking the atmosphere for granted to a state of serious concern about its continued existence in the form that sustains life. This awakening has come about largely as a result of observations from space, which have altered our perception of the atmosphere, and our environment in general, from one of an essentially infinite and imperturbable medium to that of a limited and precious resource. We have seen that other Earth-like planets have extremely hostile environments. This suggests that our own may not be stable. Indeed, we have always known this to be the case from the ice ages and less extreme, but more recent, recorded fluctuations. The famous Elizabethan ice fairs on the River Thames and the relatively balmy weather of the 1930's are examples of this. Very recent years have shown evidence of record-breaking extremes (severe winters in North America, droughts in Britain) which may signal a significant climate fluctuation beginning in our own time. Finally, the recent bouts of pollution-induced human discomfort and crop loss in many parts of the world remind us that human activities now occur on such a scale that global consequences are possible.

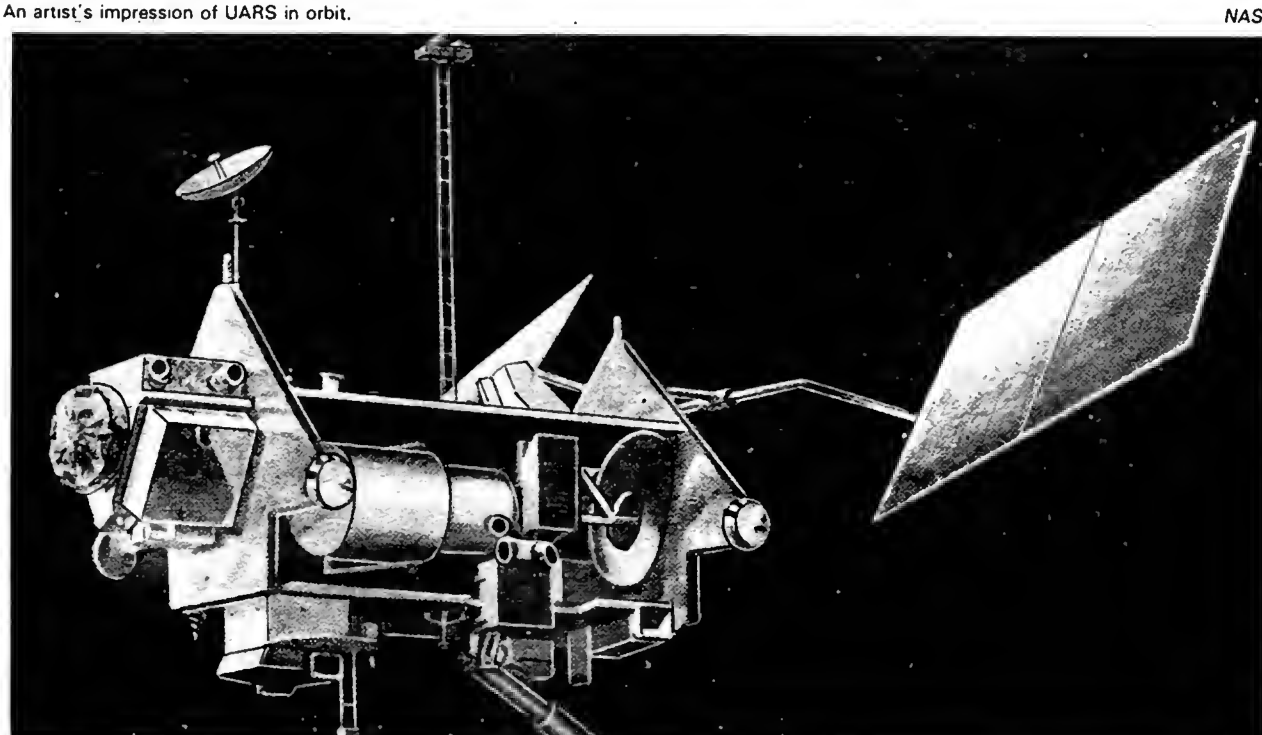
Our primary defence against undesirable climatic change is a better understanding of the atmosphere. With this, we can analyse changes and predict what might happen as a result of any particular natural or man-made perturbation. The atmosphere above the tropopause (about 10 km above the surface) is particularly susceptible to changes and exhibits in relatively simple ways the still complex interplay between radiation, chemistry and dynamics which characterises the behaviour of atmospheres everywhere. It has thus become one of the principal focusses of scientific research in recent years.



Nimbus 7 provided the first global high resolution maps of total ozone content of the atmosphere. NASA

Because climate is a global-scale or planetary phenomenon, the use of space observatories to gather data that span all latitudes, seasons and times of day is essential. The instrumentation needed is generally in the form of sophisticated spectrometers which are large and massive compared to the relatively modest and compact cameras and radiometers that sound and map the temperature and cloud structure of the lower atmosphere for meteorological and other purposes. Thus, an advanced upper atmosphere observatory was not practical until the Shuttle era; UARS was born at the same time as the

An artist's impression of UARS in orbit. NASA



Shuttle and will be one of the first 'free flyers' to take full avantage of the massive lifting capacity.

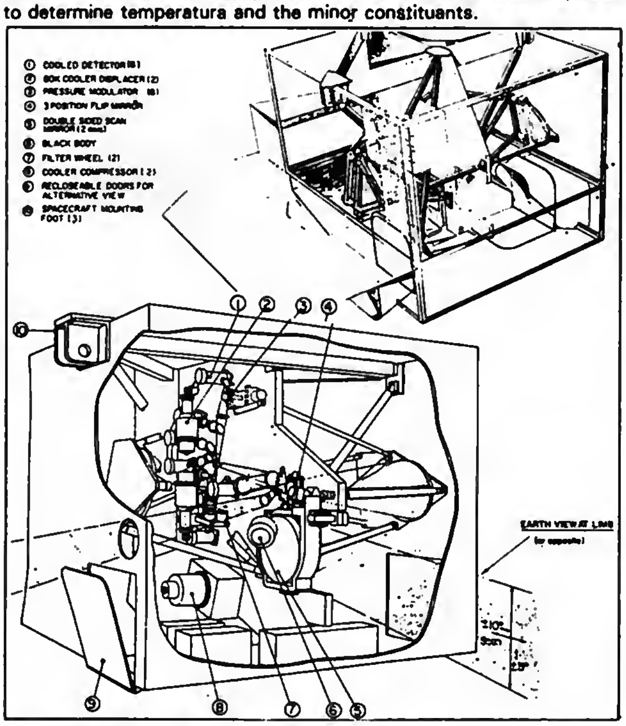
The Satellite

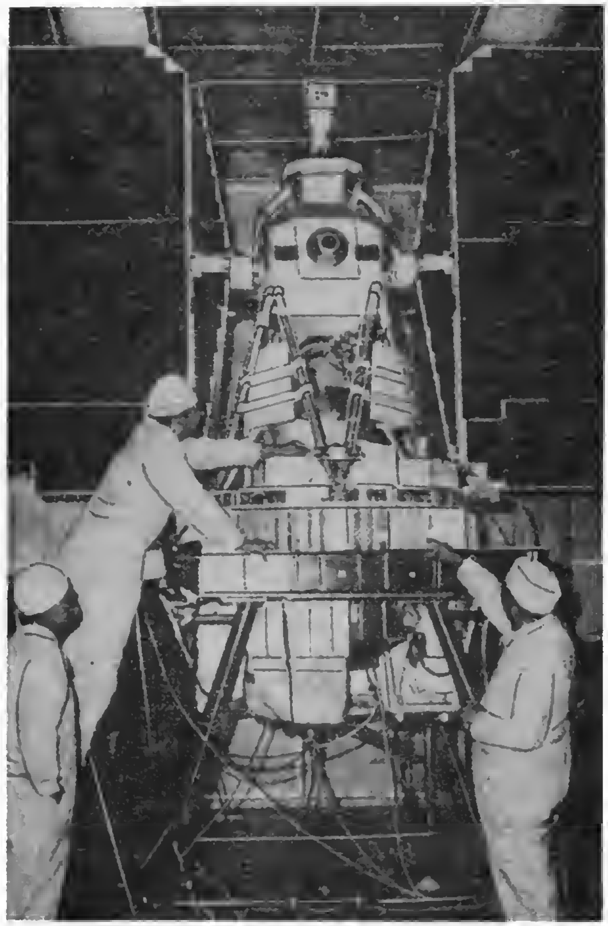
UARS will be placed in a 600 km orbit in the autumn of 1989. It is 6.4 m long, 4.6 m in diameter and weighs approximately 5 tonnes; some 1500 watts of power are consumed by the spacecraft subsytems and its scientific payload of 11 instruments. The inclination of its orbit is designed to allow good latitude coverage. Allowing for the fact that modern atmospheric instruments are limb sounders, that is they look towards the horizon rather than down at the surface, coverage of all latitudes between 80°N and 80°S will be possible - over 98% of the Earth's surface.

The measurements will be straightforward: temperature, pressure, composition and wind as a function of height, latitude, longitude and time. A single satellite cannot cover all of the dimensions often enough, so the actual procedure is a compromise worked out in laborious (sometimes excruciating) detail by the science team selected by NASA to run the mission. This is made up of experimentalists, who also provide the sophisticated sensors to be mounted on the satellite, and theoreticians, who develop computerised models of the atmosphere and who represent the potential consumers of the data. The compromises include determining the resolution required to reveal behaviour on various spatial and time scales. For example, an instrument scanning vertically can do so in very small steps to reveal interesting fine structure, such as vertically propagating waves, which may have wavelengths of only a kilometre or two. However, fine vertical sampling takes longer - typically around 30 seconds per profile - and results in coarser horizontal sampling because the spacecraft is travelling forward with its orbital velocity of around 7½ km/s.

Temperature as a function of pressure is the most fundamental atmospheric structure parameter. This is usually determined by measuring the intensity of infrared emission from atmospheric carbon dioxide, which is present in known and virtually constant amounts. Once this has been done, emission from other species of interest can be interpreted in terms of their abudance, since the intensity of the emission depends on the number of molecules present and their temperature.

The ISAMS sensor will study infrared radiation from the atmosphere to determine temperature and the minor constituents.





The Nimbus 7 satellite, launched in 1978, carried eight remote sensing instruments. UARS will begin a new generation. *NASA*

The most interesting minor constituents in the upper atmosphere are water vapour and ozone and the various species (many of man-made origin) that react chemically with them. Among these are the nitrogen compounds (particularly the various nitrogen oxides, mostly derived chemically from nitrous oxide originating at the Earth's surface) and the chlorine family (including those derived from freons, still widely used as refrigerants and as propellants in aerosol sprays). All have characteristic groups of emission lines in the infrared and microwave parts of the spectrum and can be distinguished and monitored by a sufficiently refined instrument. Note that since infrared and microwave emissions are measured, the measurements do not rely directly on solar illumination. Since the variability of the photochemical products with time of day is one of the most interesting changes to be studied, it would not do to have the measurements themselves also depending on the Sun. Furthermore, emission measurements can follow changes on the night side. The price is the need for very sensitive instruments; on UARS this is achieved by cooling to very low temperatures and by large aperture collecting optics. Examples are the infrared instruments called CLAES (see table), which carries with it about 300 kg of solid hydrogen, and the microwave instrument (MLS) which has a collecting dish 1.5 metres high.

In addition to studying the atmosphere itself, UARS also has instruments that look upward, away from the

JAPAN'S HALLEY PROBES

By Neil W. Davis

Japan will shortly launch the first of its two Halley's comet probes. The author describes the basics of the missions.

Introduction

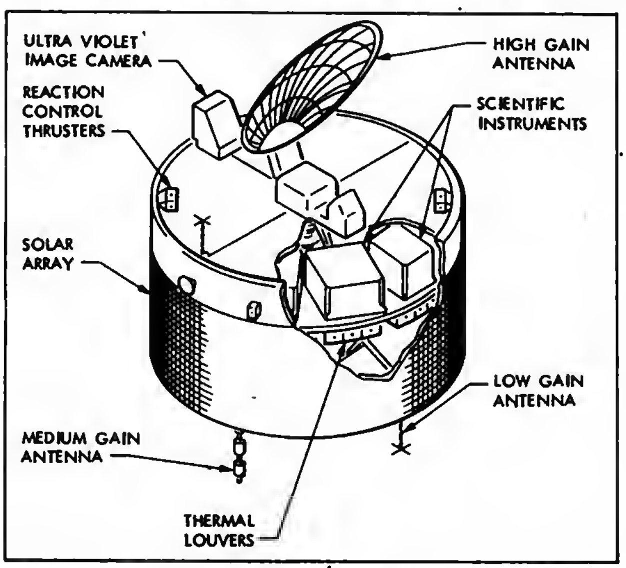
Professors at the Institute of Space and Astronautical Science (ISAS) in Japan are completing the final preparations for their first interplanetary probes, a pair of spacecraft that will observe Halley's comet early in 1986. According to Kuninori Uesugi, associate professor in the Space Systems Engineering Division, three major new projects support the missions: an upgraded launch vehicle, a new launch building at the Kagoshima Space Centre and a newly-completed 64 m diameter tracking, telemetry and command dish antenna.

The main Japanese probe, 'Planet-A,' is scheduled to make its closest approach to the comet on 8 March 1986. The spin-stabilised Planet-A, 1.4 m in diameter and 70 cm in height, will travel aloft on 14 August next year and the preceding test probe 'MS-T5' on 4 January 1985; both will be injected directly into heliocentric orbits without initial Earth-parking orbits.

Planet-A will approach to within approximately 2-3 million km of the comet, though at least one of the more optimistic senior professors is confident that a distance of 200,000 km is possible. It will obtain a series of ultraviolet photographs of the hydrogen cloud using image-detecting CCD (charge coupled device) scanners made by the NEC Corporation. UV observations during the comet's immediate post-perihelion phase are of particular interest to ISAS specialists.

During its imaging cycle, Planet-A will spin at 0.2 rpm, a reduction from its 120 rpm spin at the time of its immediate post-launch phase and the 6.3 rpm spin rate while cruising towards its target. A bias momentum wheel will stabilise it during the imaging cycle and magnetic bubble memory recorders will be used to store data for later transmission to Earth. At approximately 136 kg, it is 2 kg lighter than MS-T5, according to Dr. Uesugi.

The estimated approach distance for MS-T5 is 6 million km but ISAS specialists might move it closer although ISAS researcher Dr. Hiroki Yokota reports that the 6 million km will be difficult to improve upon.



Planet-A and the orbits of Halley's comet and Earth. *ISAS*

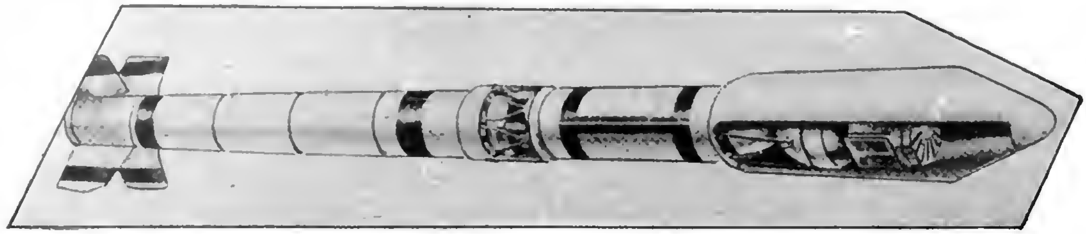
Although MS-T5 is a test probe (to verify the new launcher and TT&C dish antenna operations) it will also be used to perform observations of the solar wind's magnetic field, plasma waves and solar wind particles "downstream" of the comet's path relative to the Sun. Ion temperature and velocity, plasma density and electron temperature of the solar wind will be monitored.

Both spacecraft were integrated at the new Sagamihara ISAS space facility (40 km west of Tokyo). Their bus structures are made of light-weight CFRP (carbon fibre-reinforced plastic) by Mitsubishi Electric. For communications, they are each equipped with a despun 80 cm diameter high-gain antenna and a back-up medium-gain antenna.

The Launcher

MS-T5 will be boosted by the first 'Mu-3S II' series launch vehicle, an upgraded version of the current "Mu-3S" series. With a total weight of 61 tonnes (an increase of over 12 tonnes over the previous version), the new model features thrust augmentation of the second and third stage motors and the addition of twin strap-on boosters. All ISAS launch vehicles use solid propellant and are manufactured by the Aeronautical and Space Division of Nissan Motor Co.

A new launch building was completed in the summer of 1982 at the Kagoshima Space Centre by prime contractor Mitsubishi Heavy Industries. The ISAS 'Usuda Deep Space Center,' located in a valley 1,500 m high at Usuda town,



Top: a four stage version of the Mu-3S will be used.
Below left: a mock-up of Planet-A. *ISAS*

Nagano Prefecture (about 170 km northwest of Tokyo) was recently completed at a cost of just over $30 million, says Professor Haruto Hirosawa. A number of domestic firms were involved in the construction, with Mitsubishi Electric assuming responsibility for the 64 m antenna, NEC Corporation taking charge of the receiving and transmitting systems and Fujitsu supplying computer equipment. With a ground-based feed sub-system and four reflecting mirrors, the waveguide system of this antenna features a different design than the similarly-sized NASA deep space antenna stations.

ISAS was the first Japanese space group to orbit a satellite so it is appropriate that ISAS will launch their first heliocentric spacecraft, MS-T5. A mere month after the launch of this test probe, ISAS scientists will mark the 15th anniversary of their first successful satellite, the 24 kg 'Ohsumi.' ISAS are also considering participation in NASA's 'OPEN' programme (Origins of Plasma in the Earth's Neighborhood), according to Atsuhiro Nishida, professor of the Space Plasma Division.

Acknowledgement

The writer would like to thank Prof. H. Hirosawa, Associate Prof. K. Uesugi and Dr. H. Yokota of ISAS.

1985 SUBSCRIPTION FEES

There is good news for all members: fees for 1985 will remain unchanged from 1984 in spite of rising costs.

Direct Debit Scheme

Our old Bankers Order System has been phased out. Direct Debit slips to become effective from January 1985 are now available from the Executive Secretary. They *must* be returned before 15 Nov. or else they will not come into operation until 1986 and a separate remittance for 1985 will have to be made.

Amounts payable for the calendar year January-December 1985 are as follows:

RATES

Members	Sterling	US Dollars
Under the age of 18 years	£16.00	$26.00
Between 18 and 20	£18.00	$30.00
21 years of age and over	£21.00	$36.00
Fellows	£23.00	$40.00

Age Allowance

A reduction of £4.00 ($6.00) is allowed to members of every grade over the age of 65 years on 1 January 1985.

JBIS and *Space Education*

The additional subscription payable for *JBIS*, where required as well as *Spaceflight*, is £20.00 ($34.00). For *Space Education*, it is £4.00 ($6.00).

Methods of Payment

Europe

(a) Please pay in sterling with a cheque which shows a UK address, where it can be paid.

(b) Cheques drawn in sterling payable at a bank in Europe must include £2.00 to defray charges and collection costs. Eurocheques have no charges *only* if the account number is written on the back.

(c) Banks which remit directly to the Society must be told to see that the sum is transmitted *free of deductions*.

(d) Remittances from Europe are best made by GIRO. Our GIRO account number is 53 330 4008.

USA and CANADA

(a) US dollar cheques can be drawn on a Bank which gives an address in the United States or in the UK. US dollar cheques drawn elsewhere need to be increased by $8.00 to cover collection charges.

(b) US dollar notes are accepted.

(c) US or Canadian money orders can only be accepted if *expressed in Sterling*. Internal money orders from these countries i.e. those expressed payable in dollars will be returned as they cannot be cashed in the UK.

(d) Canadian bank remittances may easily be made in sterling drawn on their UK agents. If payment is made in Canadian dollars the current exchange rate may be used, plus the addition of 8 Canadian dollars to cover exchange and collection charges.

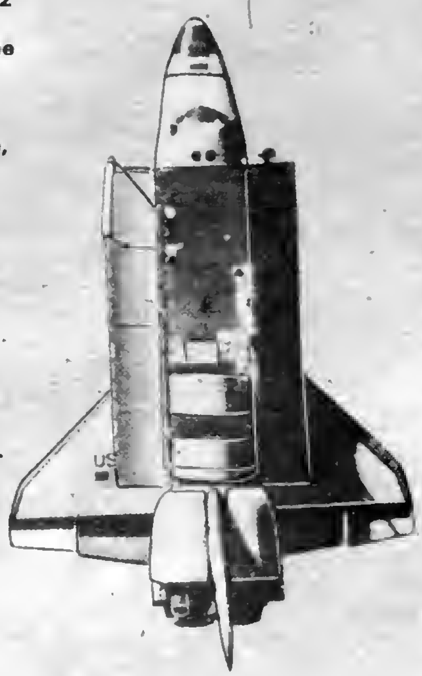
SOCIETY BOOKS

PROJECT DAEDALUS

The publication of the Project Daedalus Final Report marked the end of years of painstaking work by a group of BIS pioneers. The BIS received congratulations from around the world for its far-sighted project: designing a probe for man's first crossing of interstellar space.

The Final Report Report contains 24 papers spread over 192 large-format (A4) pages, summarising the four year study. The papers cover the overall spacecraft design, mission profile, computer systems, navigation, experiments and our knowledge of nearby stellar systems, some of them possibly with planets.

"Daedalus" is acknowledged as a milestone in the the development of advanced astronautics. Copies of the Report cost just £7.00 ($11.00) post free.



THE EAGLE HAS WINGS

An exciting progression of space achievements in the years following the Second World War led to Man's first landing on the Moon in 1969. Rockets for probing the upper atmosphere evolved into the space launchers we know today. Vanguard, Explorer, Atlas, Titan, Mercury, Gemini, Apollo – a succession of names to conjure up memories of the 50's and 60's when man was taking his first tentative steps into outer space.

The Eagle Has Wings tells the story of the major US Space projects from 1945 to the watershed year of 1975, when the Apollo missions came to an end and the first wave of interplanetary exploration gave way to the more sophisticated probes of today. Written by *Spaceflight* managing editor Andrew Wilson, it is packed with information and photographs. It runs to no less than 144 large-format pages and can be obtained for the low price of £7 ($11.00) post free.

HIGH ROAD TO THE MOON

Every member ought to own a copy of this unique 120 page publication which records many of the Society's early ideas and discussions on Lunar exploration in the visionary drawings and illustrations of the late R. A. Smith.

Pictures and drawings detail plans for orbital rockets, space probes and ships to take men to the Moon and Lunar exploration. Some are familiar illustrations used in books of the time: others have not been published before.

Bob Parkinson has brought these pictures together with a commentary which tells how the pioneers imagined things would be and how they actually were. It goes beyond the present, for man's involvement with the Moon is not yet finished. Using the Smith pictures as a background, Dr. Parkinson looks at the possible future for the Moon and how it might be brought about.

Price: £6.00 ($ 9 .00) post free.

All of the books are available from: The British Interplanetary Society, 27/29 South Lambeth Rd., London SW8 1SZ, England

THE BRITISH INTERPLANETARY SOCIETY

PERSONAL PROFILE

M.W. JACK BELL

The latest in our series of Personal Profiles concentrates on an engineer who has been closely involved with the most exciting projects of our time: Apollo and the Shuttle. The author takes up the story...

Introduction

Two years after my birth in Wichita Falls, Texas, my family moved to Oklahoma. Here, at the age of three in 1930, my interest in aviation was kindled by a flight in an open cockpit bi-plane, riding in my father's lap. In 1938 my interest in space flight began with an article in the *American Boy* magazine: "50 Miles Up" by Franklin Reck, based on an interview with Peter van Dresser, then editor of *Astronautics* magazine published by the American Rocket Society. It described the research of Robert Goddard in Roswell, New Mexico, where I often visited my aunt in summer holidays. During the following summer of 1939 my aunt refused to take me to meet Dr. Goddard, saying, "Those people don't want visitors."

She was undoubtedly right, but I have always regretted missing that opportunity.

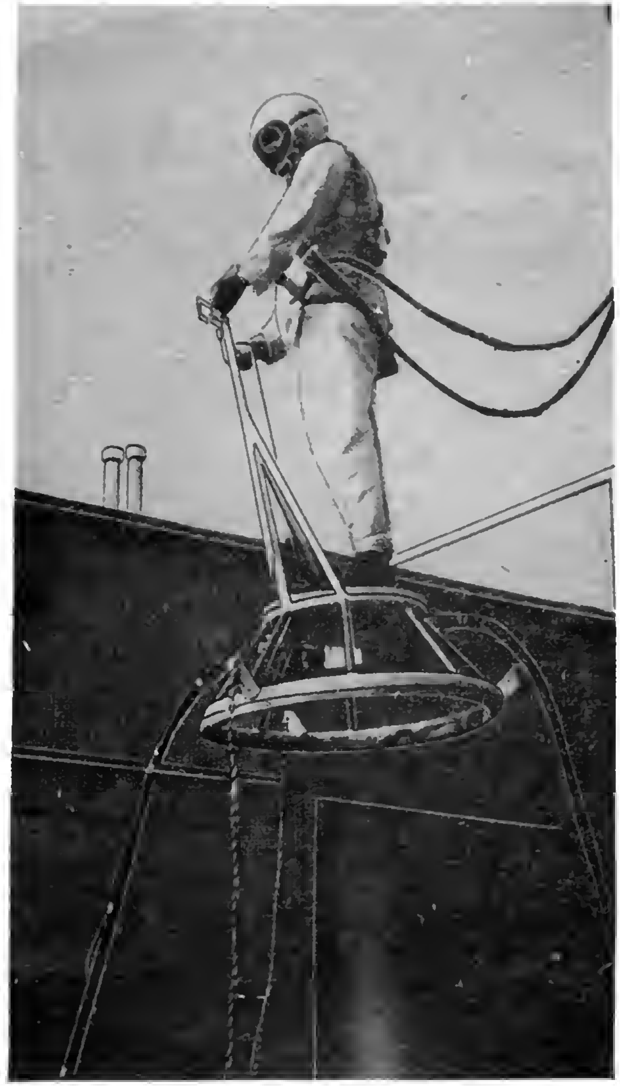
The January 1939 issue of *American Boy* had an even more exiciting article by Reck based on his van Dresser interview, "Let's Leave Earth, a Picture of Rocket Travel," describing what future manned flights to a large rotating space station would be like. I recently looked at these two pieces again and still find them to be relatively good technically.

In 1945 I entered the US Merchant Marine Cadet Corps and subsequently attended their Academy on Long Island, New York. In 1948, having a few hours liberty after taking part in a parade in New York City, I found the office of the American Rocket Society. Here I met Alice Slade, secretary of the society, who was very helpful in obtaining some excellent reference material on rockets and space travel. I became a student member of the society in early 1949.

After graduation, I sailed as a deck officer with the Alcoa Steamship Company for five years. I met and married my wife Janell Wright McDonald of Halifax, Nova Scotia in 1950 and joined the BIS as an Associate Fellow in 1952. In 1954 I left the sea to resume my education and to get a job in aviation. I worked for North American Aviation, Inc. at their Columbus, Ohio division and attended night school at Ohio State University.

My first assignment with NAA was as a junior engineer in propulsion system design on the F-86H aircraft. About then we became aware that new Soviet vehicles had a substantially higher service ceiling than our operational aircraft. Using propulsion system data I had obtained from the BIS and ARS, I devised a conceptual design for a rocket-augmented F-86H. When I reviewed this work with the Chief of Propulsion Development in early 1955, he became upset and asked who had been talking to me. No one, I assured him, showing him that all the data were readily available.

A few months later I was told that there were classified studies in progress for using a hydrogen peroxide, RP fuelled super-performance auxilliary rocket engine on the US Navy's FJ-4 aircraft. I had been selected to become "propulsion system coordinator" on this programme, based on my interest in and knowledge of rocket propulsion systems.



Jack Bell is shown testing the lunar flying platform simulator at Downey in California during June 1963. *Rockwell*

Three versions of Rocketdyne auxilliary rocket engines were tested in two modified FJ-4s, designated FJ-4Fs. The test programme was very successful, providing supersonic performance to a fundamentally subsonic airplane and the capability to out-manoeuvre any operational aircraft at that time above 13,000 m. In spite of this success, the Navy abandoned the project due to shipboard problems with hydrogen peroxide. The Rocketdyne AR-2 engine was subsequently used in better-publicised programmes to establish world altitude records.

Into Rocketry

When we started the FJ-4F programme it was apparent that engineering personnel with a knowledge of rocket propulsion systems were few. I was encouraged by NAA management to organise a Columbus, Ohio section of the ARS in the summer of 1955 and I had the honour of being elected the first section president.

As a result of independent studies on a vertically-launched manned rocket interceptor and an air-launched ballistic missile, Morgan (Mac) Blair, manager of the Advanced Design Department of NAA's Columbus Division chose me to lead his missile and astronautics systems studies in August 1957.

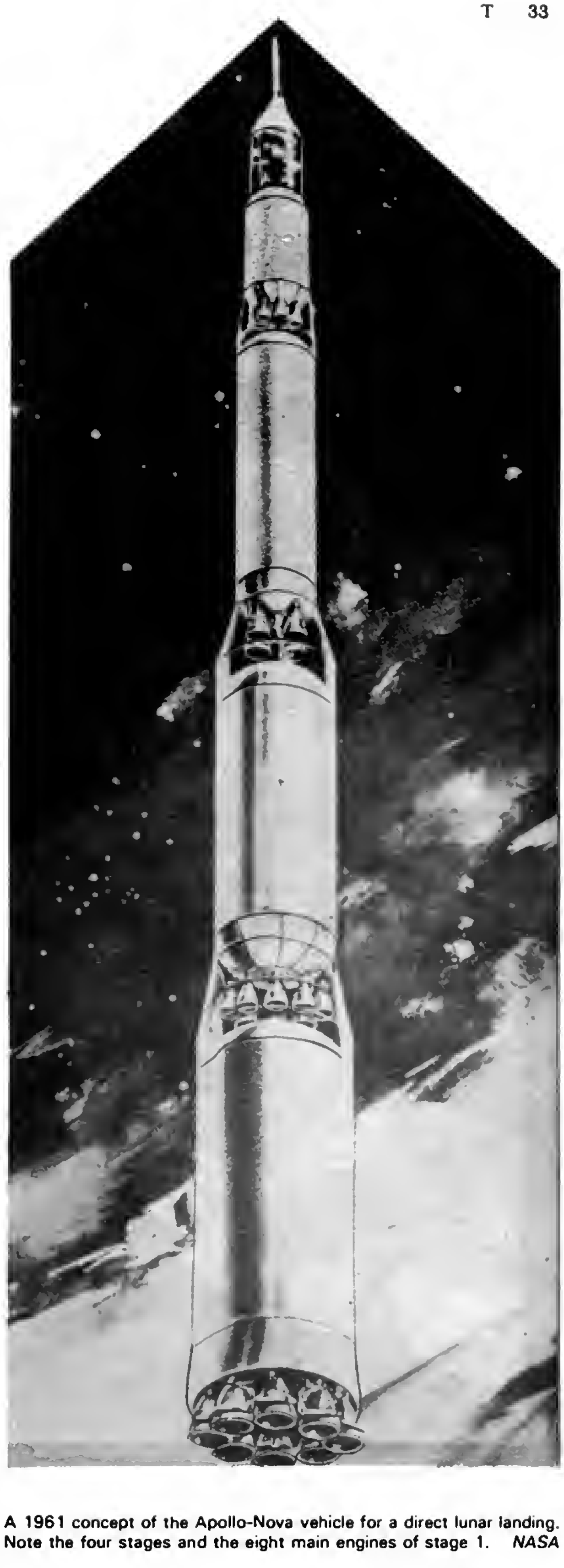
Our initial studies were performed in support of Cdr. Dewey Struble, of the US Navy's Bureau of Aeronautics,

who was evaluating concepts for air-launched satellites for providing tactical support to naval forces. Shortly after his retirement from the navy, responsibility was assigned to Capt. Robert Freitag, Astronautics Officer in the newly created Bureau of Naval Weapons. [Capt. Freitag was presented with the Society's Bronze Medal in 1979 for his contributions to astronautics *-Ed.*]

About this time primary responsibility for military space systems development was assigned to the US Air Force and NAA established its Space and Information Systems division in Downey, California. I was transferred there in November 1961, just before the Apollo contract was awarded to NAA. I then replaced Norman Ryker as Manager of Scientific Space Systems in Advanced Engineering and he became Assistant Chief Engineer on Apollo.

As then planned, Apollo was to proceed in evolutionary stages, first to Earth orbital operations, then to Earth orbital rendezvous and assembly operations for lunar missions. An alternative being considered was direct lunar flight which would require a much larger launch system, called Nova, than the Saturn 5 system then under development. Both Earth orbital assembly and Nova direct mission modes appeared to involve undesirable technical and operational risks and expense. Dr. John Houbolt of NASA's Langley Research Center had conceived the idea of a direct flight using a Saturn 5 to send the Apollo Command and Service Modules with a small lunar Landing Module to the vicinity of the Moon where the service module propulsion system would be used for deceleration into lunar orbit. From there, one man would descend to the surface in a space suit riding the open-seated lander, then referred to as the "Bug." Of course, Dr. Houbolt recognised the possibility of scaling up this concept to a multi-manned pressurised lander but his emphasis was on minimising system weight, cost and development time.

While the Apollo engineering department was assigned to proceed with developing the Command and Service Module designs, I was assigned to lead NAA's alternate lunar mission modes studies, working closely with Maxime Faget and his staff from the Space Task Group, first at Langley, then at NASA's Manned Space Center (now the Johnson Space Center), in Houston, Texas. We evaluated the comparative costs, schedules, risks and weights of Earth orbital rendezvous, lunar orbital rendezvous, and direct landing and return missions. Our studies verified Dr. Houbolt's position that lunar orbital rendezvous required the smallest Earth lift-off weight and could be done with a single Saturn 5. Owing to concern about the safety of lunar orbital rendezvous, NAA management tended to prefer a direct mission using a small two man command module. Unfortunately, this would have required the scaling up of the Saturn 5 and the development of cryogenic lunar landing and Earth return propulsion modules. In spite of the fact that Earth orbital rendezvous had not been demonstrated at that time, NASA and NAA management agreed in July 1962 upon lunar orbital rendezvous.



A 1961 concept of the Apollo-Nova vehicle for a direct lunar landing. Note the four stages and the eight main engines of stage 1. *NASA*

A Lunar Transporter

Dr. Thomas Gold, an astronomer, suggested that most of the Moon was covered with quicksand-like dust that would swallow up a lander. Observations from Earth made it apparent that there were certain to be hard outcroppings suitable for landing, even if Dr. Gold's hypothesis were correct. NAA began to study a small manually-controlled lunar flying vehicle in 1963. I conceived a stand-on rocket platform with motorcycle-type handle bars and throttle, entirely mechanically controlled without any electronics or electrical system.

I chose John Sandford, now president of De Haviland of Canada, as my project engineer. He was wary of the apparent instability and expressed concern that no-one would be able to control it. Emboldened by the success of Paul Hill at Langley, who had already demonstrated flying with strap-on air-rocket shoes, I directed John to proceed with an air-powered demonstration unit, promising to fly it first myself.

On attempting the first flight, I began to believe that

John had been right – and he had no better success in controlling the platform. I tried a second time and had resigned myself to failure when suddenly the platform was under control. I quickly realised that I was using instinctive response to stand erect on a shifting surface to stabilise myself. Reasoned control was too slow to provide stability. I moved across the ground by using a very slight tilt in the direction desired. John also quickly learned to fly the platform. In subsequent flights we used the handlebars only to damp oscillations in our ankles and for throttle control. Several astronauts later flew it successfully and they all seemed to enjoy the experience, but one commented that he couldn't see himself going all the way to the Moon just to kill himself playing on the thing.

To the Planets

In the autumn of 1963, my title was changed to Director of Lunar and Planetary Systems. My principal project from then until 1969 was the definition of systems for manned interplanetary flight.

As of 1963, General Luiggi Crocco of Italy had published papers on a Mars flyby and return mission, which are possible every 13 years and would last two years. The trajectory was assumed to be unperturbed by Mars' gravitational field. We were studying lunar "free return" missions for Apollo missions at that time and it occurred to David Hammock and myself that the Martian gravitational field could be used to modify the trajectory to permit flyby flights every two years rather than waiting for a favourable alignment of Earth, Mars and the Sun. In addition, it seemed likely that the mission duration could be shortened to something less than two years. Detailed studies by NAA and NASA subsequently confirmed this hypothesis.

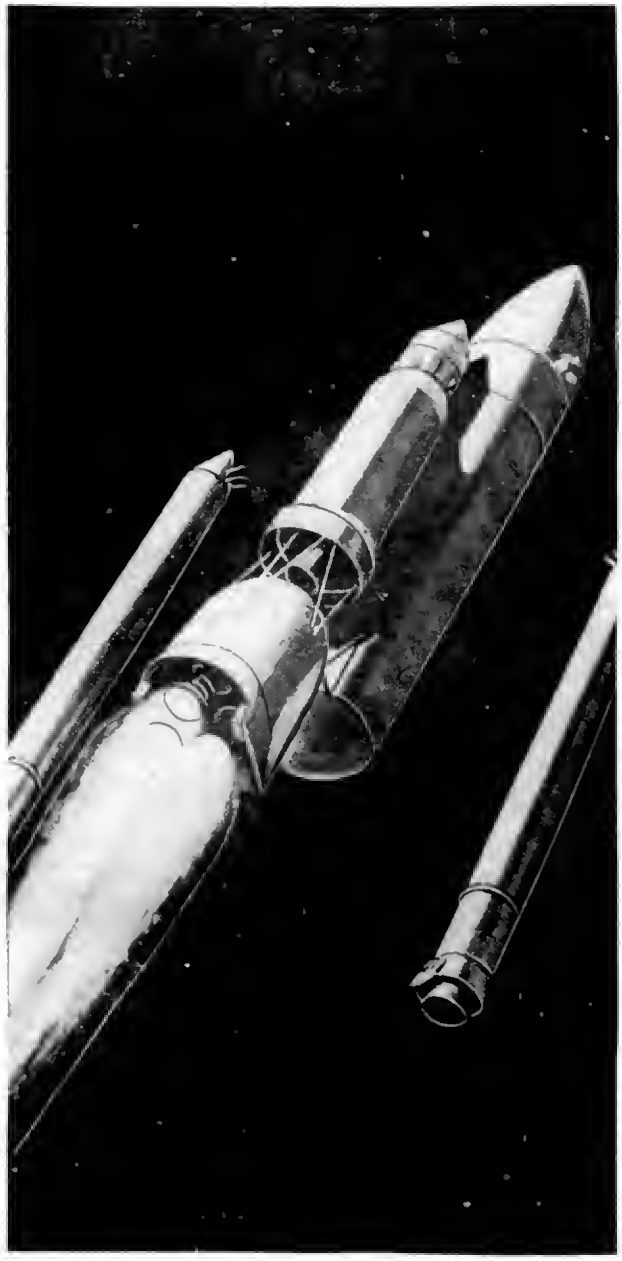
I used this fundamental concept to devise a minimum Earth lift-off weight system for a manned Mars landing and return mission, with two separate vehicles. The first is a Mars flyby craft composed of a living and observation module, an Earth entry module similar to the Apollo command module and a service module similar to Apollo's. The other is a Mars direct entry and landing module, which contains a small minimum duration ascent module for rendezvous with the flyby craft during close approach. The flyby portion leaves Earth orbit first, followed immediately after confirmation of successful injection by the direct lander which uses aerodynamic braking except for terminal touchdown upon arrival at Mars.

The second vehicle is given a higher departure velocity to allow it to arrive about two weeks ahead of the flyby section. Upon achieving rendezvous with the flyby craft the minimum ascent module is abadoned. Typical duration of such a mission is about 600 days.

When President Johnson decided not to run for re-election in 1968, prospects for any significant manned lunar or planetary missions beyond Apollo dimmed. My employer, now North American Rockwell Corporation, stopped their studies of manned interplanetary systems in late 1969.

The Shuttle

In 1972 I took part in preparing Rockwell's 'Space Shuttle Vehicle System Proposal,' directing the preparation of the draft of the systems engineering section. I became manager of Special Studies when Rockwell won the contract, leading studies of alternatives to the proposed Shuttle system baseline. One of the alternatives, the "light-weight double delta wing planform" configuration was adopted as the new programme baseline in early 1973.



A Shuttle-derivative Heavy Lift Launch Vehicle developed by Rockwell during the mid-1970's. *Rockwell*

In 1974 it became apparent that mounting jet engines on the Orbiter was inappropriate for flight tests and ferrying it around. Instead, we studied the feasibility of carrying it 'piggyback' on a modified Boeing 747 aircraft, including in-flight separation for approach and landing testing. Surprising to many people, the results were favourable and the scheme was adopted that same year.

During my last years at Rockwell before retirement in 1984 I led studies on second generation space transportation system concepts, aiming for low cost reliable space flight. As a result of the Shuttle experience, a design goal of providing a single-stage-to-orbit, fully reusable configuration was established. We concluded that significant advances in lightweight, high strength structures are required to build a aircraft-type single-stage-to-orbit, but a sustained technology development programme could provide them within a decade.

It is probably possible to develop a single-stage-to-orbit, vertical take-off, vertical landing semi-ballistic vehicle using current technology.

FROM THE SECRETARY'S DESK

Presentation to Mercury Astronauts

Looking through some old copies of *Spaceflight* (March 1962, pp.38-39) brought to light the occasion when the Society presented a Silver Plaque to the original seven Mercury astronauts.

The Presentation, arranged by Dr. Hugh Dryden, Deputy Administrator of NASA, took place at Cape Canaveral on 7 October 1961 when much of the district was still a shanty town though with new motels springing up everywhere. Present on behalf of the BIS were Dr. Les Shepherd and myself, the Plaque being received by Alan Shepard, accompanied by two other members of the original Mercury team, Gordon Cooper and Virgil "Gus" Grissom.

The lead-up to the presentation was most eventful, starting with rendezvous at NASA HQ in Washington followed by a flight in a NASA 'plane to the Cape. Dr. George Low, then Associate Administrator for International Affairs, accompanied us but, on arrival at the aircraft, we discovered that - apart from George and the air crew - we were the only passengers.

The journey was fascinating from beginning to end. There was an interesting sojourn on the flight deck, from where we could clearly see many 'planes in the same flight path though at slightly different altitudes. Since the NASA aircraft was faster, we were treated to the somewhat eerie spectacle of a succession of aircraft seemingly approaching us *backwards*, as we overtook them! Below, as we sped south, the number of smoky patches marking forest fires grew considerably, developing into red glares as night wore on.

Arrival over the Cape was a magnificent occasion because it coincided with the launch of a Titan rocket, apparently put on specially for our benefit. Witnessing this large rocket launch from the air was an incredible sight. I often referred to this in subsequent lectures as a major attempt by NASA to "down" me at an early age, but fortunately they missed.

The following morning saw us having breakfast with several of the Mercury astronauts, a most enjoyable experience in itself, marred only by my idea that I would prefer a course appropriate to the district. Alan Shepard suggested grits. That's exactly what I got.

The Presentation, which was accompanied by some extremely nice speeches (none of which, sad to say, have been recorded for posterity) took place in what appeared to be a large Portakabin but which was very comfortable nonetheless. It turned into a most graceful occasion and one of which our Society should always be proud.

Les and I rendezvoused later with Dr. Wernher von Braun who took us on a personally-conducted tour of some of the Cape facilities, including ascent by lift to the top of a Saturn rocket then being readied in the gantry. The view of the Cape, along the line of gantries stretching into the distance and with the surf and sand forming a margin between land and sea, was a unique sight.

I had already experienced some of Wernher's earlier work, *albeit* obliquely. This took place in 1945 when a V2 rocket exploded immediately overhead, shattering both surrounding glassware and one of my nine lives. Many wartime V2's arrived broadside-on and were thus destroyed in the atmosphere before reaching the ground, contrary to the generally accepted view that they all arrived nose-first, rather like arrows.

I received another lesson from Wernher some years later. This was on the occasion of the Amsterdam IAF Congress in 1958. When we met he was flat on his back, in bed and in great pain. It appeared that he had slipped a disc in an act of great gallantry, to wit, bending down to retrieve a lady's handkerchief.

I've left them on the floor ever since.

Vera Historia

Correspondence from another Society reminded me recently that I still have to undertake the task of re-

From left: Len Carter, Dr. L.R. Shepherd, Alan Shepard, Gordon Cooper and Virgil Grissom. *NASA*

writing parts of astronautics history. I feel sure it will provide an exciting and stimulating challenge, with plenty of scope for imagination, intellect and enterprise.

My first attempt a little while ago didn't turn out too well. I made the mistake of sticking to the facts, so it lacked excitement and lustre.

This sort of thing was realised long ago by Lucian of Samos, though his "Vera Historia" (True History) written around AD 160 warned readers, at the outset that:

"I write of things which I have neither seen nor suffered nor learnt from another, things which are not and never could have been and therefore my readers should by no means believe them."

His tale, of travel to the Moon in a ship caught up in a great whirlwind, ensured that posterity credited him with being the first recorded science-fiction writer.

He did more than that. He got his *title* right.

IAF Congress Photographs

One of the things we particularly lack are photographs taken at IAF Congresses, particularly at the two London Congresses in 1951 and 1959. The problem with the 1959 Congress arose from the concession given to a commercial photographer on the undertaking that he would provide the Society with a complete set of the photographs taken. These never arrived, for the reason that his business went bankrupt, hence our need to back-track to fill this gap.

A similar situation arises with practically all pre-war photographs, both of individuals and of events, and of any other material (published or private documentation) at this time.

Turn Turtle

I have, I'm sorry to say, run out of application forms to join the Turtle Club but no matter - all the males at BIS HQ are already members.

There were two reasons for this. First is the fact that there is no subscription fee, though forgetting the password can be even more expensive: it involves standing a round of drinks. Second is the requirement that Turtle members have to be bright-eyed, bushy-tailed, fearless and unafraid folk with a fighter-pilot attitude and an inclination to "stick their necks out." These were easy. Potential stumbling blocks arose with the further requirements to think *clean:* and to own a Jackass.

Started by a group of test pilots during the second world war, the club has progressed to its present position as one whose membership is diligently sought after and highly esteemed. Lots of aeronautical engineers and astronauts belong: even entertainers and financiers, too, but I've never moved in those circles or among those squares.

An Aide is an Aid

I am pleased with the new-style Society visiting cards - showing our logo, not least because they give the lie to remarks that the scorched Earth which surrounds my every resting place is identification enough.

Such cards are a good safeguard against amnesia. This was underlined at a press conference I attended some years ago on the withdrawal of Thor missiles from the UK.

Lord Hailsham (then Minister for Science) was surveying the proceedings from a raised dias as an aide, unfortunately, placed his nameplate the wrong way round, with the blank side facing the gathering. To his intense distress, Lord Hailsham beamed and drew the attention of the entire audience to the usefulness of the arrangement.

I get confused, too, when addressed as "Mr. Clarke," I can understand being mistaken for the famous author for, actually, I wrote three science fiction stories once, all for publication in Malta.

I wasn't asked to do any more after that. I must have made the Maltese cross.

Life, in its Many Shades of Black

John Baker likes the new-style *Spaceflight*. He wrote to tell us so but added that he objected to the glossy paper as this made the text difficult to read under overhead lighting, due to glare and reflection.

This is a problem with all art paper. On one hand we need glossy paper to get the best reproduction of illustrations but, on the other, it can sometimes cause reading problems in artificial light.

This must be a reverse of the old adage about 'It's an ill wind which brings no good.' In this case it reads 'It's a good wind that brings no ill.'

It's the Thought that Counts

An off-beat question the other day asked "What was the power of the Xenon lights used to illuminate the runway for the night landing of STS-8 in September 1983?"

I didn't know, but it moved me sufficiently to pull out the book on "Useless Information" kindly presented some time ago for emergency use.

Actually, the book helps very little on space matters though I have already profited considerably from it. For example, it says that 50% of pigs' tails twirl clockwise and 48% anti-clockwise.

I've used this in every conversation since. Where, for example, is the missing 2%?

Roll Back the Years

One of our members, Roger Hyson, recently not only rolled back his carpet but rolled back the years as well, for underneath he discovered a copy of *The Daily Herald* of 8 February 1928 containing a report on a proposed trip to Venus. The full report, for the sake of posterity, reads:

WANTS TO GO TO VENUS

Scientist Preparing a Rocket

An American scientist, named Robert Condit, proposes to take a trip to Venus. He thinks that if he gets there he may not want to return.

Mr. Condit is busy making a machine to carry him to the far-away planet, his workshop being at Miami, the famous pleasure resort in Florida, according to the *New York Herald* (Paris edition).

The machine closely resembles a rocket. Mr. Condit has already completed one unit known as the central explosive chamber.

He is equipping the device with polarised magnetic controls, by means of which he hopes to guide his craft through the planetary system when he gets beyond the gravitation zone of the earth.

Mr. Condit believes he will be able to start on his interplanetary "hop" next month. To visitors who ask him how he proposes to return to Earth, if he reaches Venus, he replies: "I am not there yet," and adds a remark about possibly not wanting to come back.

SATELLITE DIGEST-178

A monthly listing of satellite and spacecraft launches, compiled from open sources.

The heading to each launch gives the name of the satellite, its international designation and its number in the NORAD catalogue. Launch times are given in Universal Time and are accurate to about five minutes except where marked with an asterisk, where the time is to the nearest minute as announced by the launching agency.

Robert D. Christy

Continued from the November issue

SOYUZ T-12 1984-73A, 15119

Launched: 1741*, 17 Jul 1984 from Tyuratam by A-2.
Spacecraft data: Neer-sphericel orbitel compertment, conical re-entry module and cylindrical instrument unit with solar panels. Length approx 7.5 m, diameter 2.2 m and mass around 7000 kg.
Mission: Carried visiting crew of Vladimir Dzanibekhov, Svetlana Savitskaya end Igor Volk to Salyut 7. Savitskaya was the firat woman to meke e second space flight and during the mission became the first female space walker during a 4 hour EVA on 25 Jul. Soyuz T-12 docked with the rear port of Salyut 7 at 1917, 18 Jul, it landed et 1255, 29 Jul 1984 after 12 days.
Orbit: Initially 198 x 225 km, 88.66 min, 51.60°, and then by way of a 276 x 309 km transfer orbit to the docking with Salyut 7 at 334 x 354 km, 91.36 min, 51.60°.

COSMOS 1582 1984-74A, 15121

Launched: 0830, 19 Jul 1984 from Plesetsk by A-2.
Spacecraft data: Possibly based on the Voatok manned spacecraft with spherical re-entry module, instrument unit and e cylindrical, supplementary payload at the forward end. Length about 6 m, max diameter 2.4 m, and mass eround 6000 kg.
Mission: Military photo-reconnaissance, all or part of the payload was an Earth resources package. Recovered after 14 days.
Orbit: 213 x 279 km, 89.49 min, 82,35°.

COSMOS 1583 1984-75A, 15123

Launched: 1240, 24 Jul 1984 from Plesetsk by A-2.
Spacecraft data: Similar to Cosmos 1582.
Mission: Photo-reconneissance, recovered after 15 days.
Orbit: 356 x416 km, 92.31 min, 72.89°.

COSMOS 1584 1984-76A, 15131

Launched: 0900, 27 Jul 1984 from Plesetsk by A-2.
Spacecraft data: Similar to Cosmos 1582.
Mission: Photo-reconnaissance, all or part of the payload waa an Earth resources package. Recovered after 14 days.
Orbit: 180 x 365 km, 90.01 min, 82.35°.

COSMOS 1585 1984-77A, 15142

Launched: 1230, 31 Jul 1984 from Tyuratam by A-2.
Spacecreft data: Similar to Cosmos 1582.
Mission: Military photo-reconnaissance.
Orbit: 174 x 302 km, 89.27 min, 64.73°, manoeuvrable.

GORIZONT 10 1984-78A, 15144

Launchad: 2137, 1 Aug 1984 from Tyuratem by D-1-E.
Spacecraft deta: Cylinder with a pair of solar panels plus an aeriel array at one end. Length 5 m, diameter 2 m and masa in orbit approx 2000 kg.
Mission: To provide telephone, telegraph and TV relay links within and outside the USSR.
Orbit: Geosynchronous above 80°E longitude.

COSMOS 1586 1984-79A, 15147

Launched: 0839, 2 Aug 1984 from Plesetsk by A-2-e.
Spececraft date; Possibly a cylindrical body with e conical motor section, deriving power from a 'windmill' of six solar panels. Length ebout 4 m, diameter 1.6 m and mass eround 2000 kg.
Mission: Missile early warning satellite.
Orbit: Initially 801 x 39339 km, 709.38 min, 82.94°, then raised to 609 x 39737 km, 717.61 min, 62.98° to ensure daily repeata of the ground track.

GMS-3 (HIMAWARI 3) 1984-80A, 15152

Launched: 2030, 2 Aug 1984 from Tenegashima by N-II.
Spacecreft date: Cylindrical body 4.4 m high end 2.15 m diameter, apin stabilised et 100 rpm with e de-apun aerial array. The mass is 303 kg, reducing to 287 kg at the end of the misaion es fuel is depleted. The body ia covered by solar cells.
Mission: Within e five yeer design life, to provide meteorological images in four visible end one infrered spectrel bend. Information is also being gethered on the fluxes of protons, electrons and elphe particles in the region of the satellite.
Orbit: Geosynchronous above 140°E.

ECS 2 1984-81A, 15158

Launched: 1333*, 4 Aug 1984 from Kourou by Ariane 3 (flight V10).
Spececraft date: Box-sheped body 2.4 x 2.2 x 2.2 m with 13.8 m span solar array. At one face of the box ia en Earth pointing aerial array. The vehicle is three-axia stabilised uaing momentum wheels; atation keeeping is by hydrazine thruaters. The masa is 700 kg.
Mission: Provision of telephone end TV links between member countries of the European Poat & Telecommunications Conference and the European Broadcaating Union, respectively. The design life is seven years.
Orbit: Geosynchronous above 7°E.

TELECOM 1A 1984-818,.15159

Launched: 1333*, 4 Aug 1984 along with ECS 2.
Spacecraft date: Box-shaped body 2.0 x 1.4 x 1.4 m with a 16 m span solar array. At one face of the box is an Earth pointing aerial array. The vehicle is three axis stabilised using momentum wheels; station keeping is by hydrazine thrusters. The mass is 690 kg.
Mission: French satellite providing national buisness communications, overseas telephone and television links and military point-to-point communications. The satellite is the first of three end has a design life of aeven years.
Orbit: Geosynchronous ebove 8°W.

COSMOS 1587 1984-82A, 15163

Leunchad: 1400, 6 Aug 1984 from Plesetsk by A-2.
Spacecraft data: Similar to Cosmos 1582.
Mission: Military photo-reconnaissance, recovered after 25 deys.
Orbit: Initially 197 x 368 km, 90.20 min, 72.85°, manoeuvred to 356 x 416 km, 92.31 min, 72.87° efter 12 deys. Satellites using this orbit normally achieve it within two days of launch.

COSMOS 1588 1984-83A, 15167

Launched: 2250, 7 Aug 1984 from Tyuratem by F-1.
Spacecraft data: Not available.
Mission: Electronic reconnaissance over ocean areas.
Orbit: 426 x 446 km, 93.30 min, 65.03°, maintained by a low thrust motor.

COSMOS 1589 1984-84A, 15171

Launched: 1212, 8 Aug 1984 from Plesetsk, possibly by F vehicle.
Spacecraft data: Not available.
Mission: Possibly a geodetic satellite.
Orbit: 1494 x 1502 km, 116.00 min, 82.60°.

MOLNIYA-1 (61) 1984-85A, 15182

Launched: 0004, 10 Aug 1984 from Plesetsk by A-2-e.
Spacecraft data: Cylindrical body with conical motor section at one end, deriving power from a 'windmill' of six solar panels. Length 3.4 m, diameter 1.6 m and mass around 1800 kg.
Mission: Communications satellite providing telephone, telegraph and TV links through the 'Orbita' system.
Orbit: Initially 423 x 40796 km, 735.37 min, 62.86°, then lowered to 718 min period to ensure daily ground track repeats.

UPDATE

COSMOS 1576 (1984-66A) re-entered or deceyed on 24 Aug 1984 after 59 days.

BOOK NOTICES

A Hundred Billion Stars
M. Rigutti, The MIT Press, 126 Buckingham Palace Road, London SW1W 9SD, 285pp, 1984, £23.75.

This book begins with consideration of the Solar System, starting with the Sun and then moving outwards towards the hundred billion stars which constitute our Galaxy. Among the subjects clarified along the way are the sources of the Sun's energy, measurements of the distance, magnitude, temperature and mass of stars; their spectral classification; importance of binary stars; the nature of pulsars, supernovae and planetary nebulae and the life cycles of stars.

This is a book for the non-scientist and even though some slight knowledge of mathematics is required, it is extremely clear and easy to read and the diagrams most attractively set out.

The Light-Hearted Astronomer
K. Fulton, AstroMedia Corp., P.O. Box 92788, Milwaukee, WI 53202, USA, 115pp, 1984, $6.95.

This book is fun. It is really a compilation of advice to the would-be amateur astronomer, part of which takes the form of Question and Answer while much consists of homilies which compare theory with practice.

Generally speaking, the text is aimed at those interested in astronomy but very inexperienced and thus in need of advice. This advice really is given, but in a most informal manner and starting even with the first appraisal of advertisements! From there one goes through the acquisition of telescopes (including showing them off to friends and neighbours), accessories and then actual observing.

This text must not, however, be confused with a straightforward observers book. It is lively and highly amusing, yet seeded with a good deal of commonsense and down-to-Earth experience. The axiom "All aid short of actual help" which applies to many observers guides does not apply here. This book, wittily and leisurely, really does help.

Astrodynamics 1983 Vols I and II
Ed. G.T. Tseng *et al*, Univelt Inc., P.O. Box 28130, San Diego, California 92128., 1325pp, 1984, h/c $120, s/c $90.

This two volume set, Vol 54 of the AAS Advances in the Astronautical Sciences series, is the product of an international symposium held in Taiwan under the sponsorship of the National Cheng-Kung University and the American Astronautical Society. About 100 papers are published, covering such areas as measurements and controls, chemical engineering, aerospace science and technology, computer applications, dynamics and control, composites and other materials. Since the total quantity of papers presented would have brought about volumes of 2000pp or more, considerable editing and synthesising has been made.

Total Eclipses of the Sun
J.B. Zirker, Van Nostrand Reinhold Co. Ltd., Molly Millars Lane, Wokingham, Berkshire, RG11 2PY, 210pp, 1984, £23.40.

Eclipses, at one time, were blamed for everything from natural disasters to the fall of kings but have now taken their rightful place as invaluable tools for the understanding of many solar as well as terrestrial phenomena.

This book explains how eclipses have been used in scientific investigations and describes a wide range of recent experiments, including those carried out by space vehicles. The causes of solar eclipses, their duration and paths of totality are all fully examined.

Particularly interesting is the nature of the Sun's corona. What causes it to be so much hotter than the rest of the Sun? Do gravity waves exist in the Earth's atmosphere: how does the Sun's gravity affect the Earth's spin? Studies conducted during eclipses have helped to answer these and many other intriguing questions yet, at the same time, opened up the possibility of making many new discoveries in various areas of science.

This is not only an excellent review for the professional but a clear and easy-to-understand guide for the amateur astronomer as well.

Astrophysical Techniques
C.R. Kitchen, Adam Hilger Ltd., Techno House, Redcliffe Way, Bristol BS1 6NX, 438pp, 1984, £15 paperback.

The aim of this book is to provide a coherent state-of-the-art account of the instruments and techniques currently used in astronomy and astrophysics. It starts from first principles to describe and explain each method up to the point at which readers can undertake practical work themselves using such equipment.

A secondary aim is to reduce the current trend of fractionation of astronomical studies. This has arisen, partly, because the new techniques needed to observe in the more exotic regions of the spectrum give rise to their own fund of ideas and terminology, and thus to the mistaken impression that what are essentially identical underlying processes are somehow different. This underlying unity is emphasised in the volume by adopting, wherever possible, the sequence of detection-imaging-ancillary instruments which apply to observations encountered, together with those similar stages applicable to other information carriers.

Each chapter contains a number of exercises (fortunately with answers) and there is a comprehensive bibliography and a number of tables as appendices.

Catalogue of Radial Velocities of Galaxies
G.G.C. Palumbo *et al.*, Gordon and Breach, Science Publishers, Inc., One Park Avenue, New York, NY 10016, U.S.A., 575pp, 1983, $94.

It is interesting to note that the numbers of known galaxy radial velocities beginning with Slipher's early measurements of 13 objects in 1914 and reaching about 800 in 1955 will, by the year 2000, probably run to about 52,000.

This catalogue lists 8,250 galaxies and represents a major effort to produce a list of all the galaxy velocities published before the end of 1980. The availability of a single reference source for all these measurements is most invaluable. However, as the authors point out, users should be cautioned that erroneous measurements or misidentifications long since cleared up may be listed here as in their original papers. Evidently, a simple or weighted average of published values, particularly discordant values, should not be used as a basis to estimate the most probable radial velocity of a galaxy.

This present collection of raw data clearly demonstrates the need for a repeated and independent programme of redshift determinations. This would be particularly valuable in a field long dominated by only a few observers and who, no matter how competent or careful, cannot possibly be immune to misidentifications and other errors. In general, all the redshifts of bright galaxies currently based on one old optical determination should be now be re-observed.

Most of the above notes are not reviews in the ordinary sense but have been extracted from information provided by the publishers and/or authors, amplified by further brief comment where appropriate.